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World War II Infantry Anti-Tank Tactics

CEN

Gordon L Rottman • Illustrated by Steve Noon

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First published in 2005 by Osprey Publishing, Midland House,
West Way, Botley, Oxford OX2 0PH, UK
443 Park Avenue South, New York, NY 10016, USA
Email: info@ospreypublishing.com

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ISBN 1 84176 842 1

A CIP catalogue record for this book is available from the British Library

05 06 07 08 09 10 9 8 7 6 5 4 3 2 1

Editor: Martin Windrow
Design: Alan Hamp
Index by Alan Thatcher
Originated by The Electronic Page Company, Cwmbran, UK
Printed in China through World Print Ltd.

FOR A CATALOGUE OF ALL BOOKS PUBLISHED BY
OSPREY MILITARY AND AVIATION PLEASE CONTACT:

NORTH AMERICA
Osprey Direct US, 2427 Bond Street, University Park, IL 60466, USA
Email: **info@ospreydirectusa.com**

ALL OTHER REGIONS
Osprey Direct UK, P.O. Box 140, Wellingborough,
Northants, NN8 2FA, UK
Email: **info@ospreydirect.co.uk**

www.ospreypublishing.com

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Abbreviations used in this text:

AA	anti-aircraft
AFV	armoured fighting vehicle
AP	armour-piercing
APC	armour-piercing capped
AT	anti-tank
HE	high explosive
HEAT	high explosive anti-tank (shaped charge)
HEP	high explosive plastic (squash head)
-pdr	pounder (British gun designation)
PzKw	*Panzerkampfwagen* (German, 'tank')
rpm	rounds per minute
TD	tank destroyer
WP	white phosphorus

Other abbreviations for weapon designations are explained in the text.

Linear measurements:

Both US/British and metric measurements are generally given in this text, but *metres* in continental range estimates have been given simply as *yards*.
For exact conversion, note:

feet to metres	= multiply feet x 0.3058
yards to metres	= multiply yards x 0.9114
miles to kilometres	= multiply miles x 1.6093

WORLD WAR II INFANTRY ANTI-TANK TACTICS

INTRODUCTION

INFANTRY ARE INSEPARABLE FROM TANKS, both in the assault and in an integrated anti-tank defence. This concept was understood almost immediately upon the first fielding of tanks, and became a basic precept of tank and anti-tank warfare:

'Tanks unaccompanied by infantry cannot achieve decisive success; they must be supported by infantry, who alone can clear and hold ground gained... If [enemy] tanks succeed in penetrating the line, the [friendly] infantry must hold out and concentrate all their efforts on stopping the advance of the enemy's infantry, while the hostile tanks are dealt with by our artillery. The defeat of the enemy's infantry must therefore be the first consideration in all plans for anti-tank defence.' These statements are found in the US Army's *Instructions for Anti-tank Defence (Provisional – February 1918), from an Official British Document.* Other than the fielding of dedicated anti-tank weapons, these concepts remained unchanged throughout World War II.

The first dedicated anti-tank weapon: the massive German 13.2mm single-shot, bolt-action Mauser Tank Abwehr Gewehr *(T-Gewehr)* of 1918, held here by an American officer, weighed 16kg (35.27lb). It was normally supported on a bipod attached to the barrel band at the end of the forearm.

At the beginning of World War II most countries had a basically sound anti-tank doctrine. The fatal flaw was that the effect of employing the tank in large combined arms formations was not fully understood. France had placed complete faith in its underpowered anti-tank guns, deployed in depth. In spring 1940 the Germans massed seven Panzer divisions on the weak Ardennes front, attacking through an unexpected sector and overwhelming French defences. Once they broke through they thrust deep into the rear, completely dislocating French attempts to respond. The French still viewed tanks as infantry support weapons; they never massed their armour, supported by other arms, to manoeuvre against breakthroughs.

The 1940 *Blitzkrieg* sent other armies into near panic, and a rush to find a means of countering it ensued on both sides of the Atlantic. The fear was often exaggerated, convincing some that infantry units were helpless against tanks. Often the planning committees looked only at the tank itself, and did not consider the combined arms aspects of German doctrine; but effective anti-tank defence would also have to be a combined arms effort.

Anti-tank tactics and weapons were in a constant state of evolution throughout the war. Improved models of tanks, evolving armour tactics, new field innovations and the overall development of combined arms tactics all contributed to this process. Anti-tank weapons changed drastically: there was a constant search for more lethal, more accurate, longer-ranged, more compact and lighter weapons. While improved tank designs and increased armour protection greatly influenced the development of anti-tank weapons, those other factors were equally important.

THE TANK THREAT

From their first use by the British Army on the Western Front in September 1916, infantry has perceived tanks as a 'terror' weapon capable of routing troops, piercing defensive lines and driving deep into rear areas. Considering the limitations of period anti-tank weapons, there was considerable justification for this fear.

To understand the capabilities and limitations of anti-tank weapons and tactics, one must be familiar with the capabilities and limitations of tanks. Tank design evolved so rapidly during World War II, and the characteristics of individual models differed so markedly, that generalizations are difficult. In any discussion of general strengths and weaknesses it must be borne in mind that these do not necessarily apply, in specifics or in comparable degree, to all tanks.

At the beginning of World War II the light tank was the most common class. (The use of small two-man 'tankettes' – weighing from 2 to 6 tons, armed with machine guns, and vulnerable to AP small arms ammunition and grenades – had all but ceased, although Japan and Italy retained them.) Light tanks weighed some 6 to 15 tons, with comparatively thin armour usually vulnerable to the modest anti-tank guns of 1939–41. They had a crew of two to four men, and were generally armed with a 37mm main gun, though often only with machine guns.[1] Their principal role was scouting, and acting as 'light cavalry outriders' for heavier tanks; however, in less affluent armies the light model was sometimes the principal combat tank. As the war progressed light tanks fell from favour because of their vulnerability; lightly armoured scout cars, with a high degree of mobility and speed, better served the reconnaissance role. Some light tanks were retained in secondary roles, and some new 'light' models were fielded with almost the capabilities of early-war medium tanks.

Medium tanks were more heavily armoured; they were usually capable of withstanding light AT gunfire, and to some extent medium calibre AT guns, at least from the front. They were generally in the weight range 15 to 30-plus tons, had crews of four or five, and mounted main armament of between 47mm and 76mm calibre. Mediums were often viewed as supporting tanks, providing heavier calibre, longer-ranged guns to support their light counterparts. Initially their speed was comparatively slow.

As it was realized that medium tanks provided the best overall capabilities

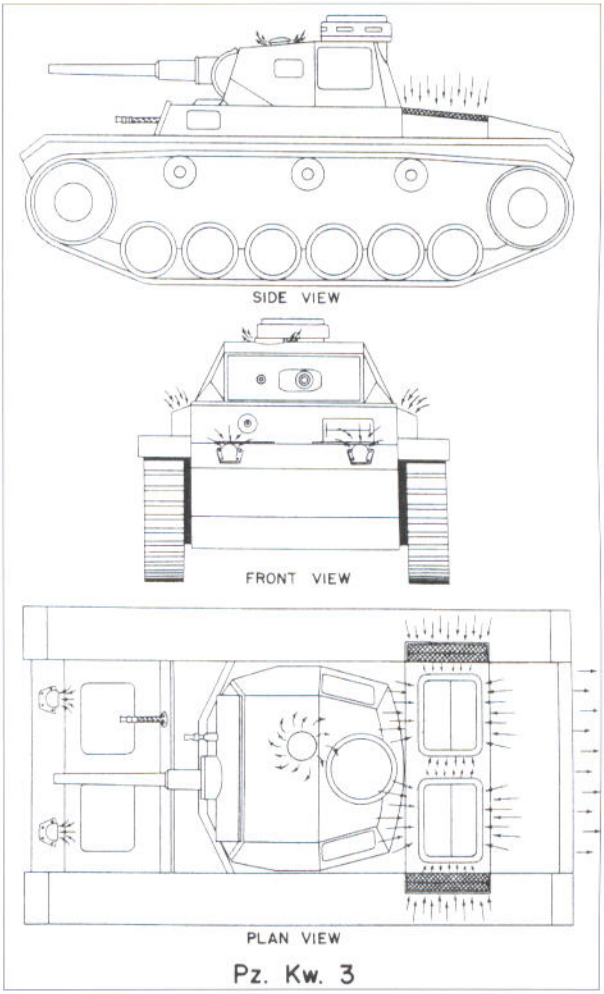
Tank design and capabilities varied greatly during World War II; this German PzKw IV Ausf F of 1941 may be considered a typical medium tank of its day. The thickest armour (50mm – 2in) is on the hull and turret fronts and the gun mantlet; turret sides and rear are 30mm, upper glacis 25mm, hull sides and rear 20mm, hull roof 15mm, turret roof 10mm. Early in the war the main gun was optimized for infantry support – here a short-barrelled 7.5cm for knocking out field fortifications. By 1943 the role of the tank had evolved; long-barrelled high velocity guns were being mounted, to fight a new generation of enemy tanks led by the Soviet T-34.

1 Note that in German documents calibres of weapons larger than small arms are always given in centimetres, e.g. 37mm = 3.7cm.

to withstand improving AT weapons, to manoeuvre, provide fire support, and fight other tanks, so their capabilities were steadily upgraded. Armour and speed were improved, and while the gun calibre was seldom increased beyond 76mm, weapons were upgraded to offer longer range and more penetration. In the second half of the war mediums, in the character of 'general purpose' tanks, appeared in overwhelmingly greater numbers than other classes.

A sub-category of mediums was the 'infantry tank', a product of two opposing schools of thought. Some planners believed that two separate tank types should be provided, one to fight other tanks (in the British term, 'cruiser tanks'), and the other to support the advance of infantry. The latter were generally more heavily armoured, and mounted a gun intended to knock out enemy positions; they could be slow, since they had only to keep pace with the infantry.

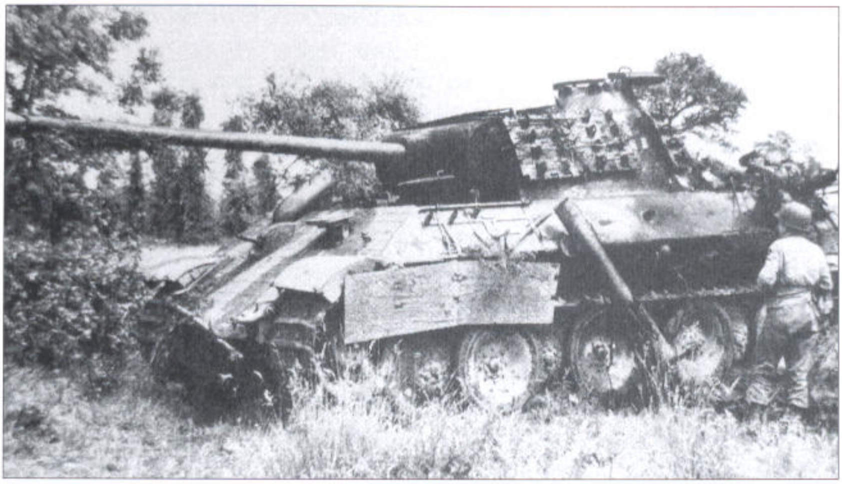
While some examples of what could be termed heavy tanks existed at the beginning of the war, their tactical purpose was not carefully thought through; they were multi-gun, heavily armoured, and very slow. More effective heavy tanks began to appear midway through the war. Designers strove to provide a mount for a heavy high velocity gun, of between 88mm and 122mm, capable of killing any tank at long range, under armour sufficient to defeat medium tank guns and infantry AT weapons. They were generally slow and very heavy (55–70 tons), which limited cross-country and even road mobility, as many bridges could not support them. They were present on the battlefield in only small numbers, but when skilfully employed they might have a definite, and occasionally a decisive effect.



Tanks had other vulnerabilities apart from penetration of the armour. This diagram, from a US intelligence report, indicates air intakes for both the crew and engine, and engine exhausts, of a German PzKw III. Such vents were vulnerable to fire bombs, smoke and gas.

While other types of armoured fighting vehicles (AFV) were encountered by the infantry, most were relatively vulnerable to light AT weapons. These included scout cars, reconnaissance vehicles, halftrack personnel carriers, and self-propelled assault and anti-tank guns. Only two of these types presented a threat comparable to that of tanks: the assault gun and the tank destroyer. Both were built on tank chassis, giving them the same mobility as tanks. Assault guns lacked a revolving turret, having the main gun mounted with limited traverse in a heavily armoured hull superstructure. These were mainly infantry support weapons, but some mounted longer guns capable of anti-tank fire (though the lack of a rotating turret greatly limited this ability). Tank destroyers – self-propelled AT guns – sometimes had a rotating turret, but this often had an open top, and the vehicles' armour was lighter than that of the tanks they fought; they relied on speed or concealment for survival.

Any tank that could be seen could be hit and knocked out with the appropriate weapon. This German PzKw V Ausf A Panther was holed through the 45mm hull side armour by an AP round from a 75mm gun, which probably killed the entire turret crew. Note the track links on the turret side, and skirt plates hung along a rail on the hull side, intended to detonate bazooka rounds before they struck the hull.



Tracks and suspension – road wheels – were easily disabled by mines and other weapons which could not penetrate the hull. Replacement usually had to be done by the crew (if they survived the action, and did not have to abandon the tank); it was obviously impossible while under fire. Here a British crew replace a bogie wheel on a Sherman in Normandy; when they have finished, replacing the cut track link and tensioning the track will take more hours of back-breaking labour. (Imperial War Museum)

Essential characteristics of tanks

Tanks were shock weapons, intended to be used *en masse*, capitalizing on their armour protection, firepower and mobility. At the very least a tank was intended to protect its crew from machine gun and small arms fire, shell fragments, and anti-personnel mines. They also offered varying degrees of protection from AT fire, other tanks' guns, mortars and artillery. They could travel cross-country over uneven ground and through dense vegetation, and surmount anti-personnel and light anti-vehicle obstacles, as well as rubble in built-up areas. All these advantages had their limitations, however, depending on the specific tank model.

Despite their psychological impact on infantrymen in the open, tanks were far from being the undefeatable, unstoppable, fire-breathing monsters so often portrayed. Vulnerabilities abounded – if conditions were favourable to those fighting against them; if leaders made the right series of assessments and decisions; if the troops possessed the necessary cunning and determination; and if the situation permitted them to take advantage of varied terrain and of the constantly changing tactical situation.

Tanks are large and extremely noisy, and thus difficult to conceal. No matter how effective a camouflage pattern a tank may be painted with, or how thoroughly it is covered with vegetation, its every movement (and on dry

ground, the dust it raises) signals its presence. It is difficult to conceal from the air in all but the densest woodland, and the tracks gouged out by its passing are easily detected.

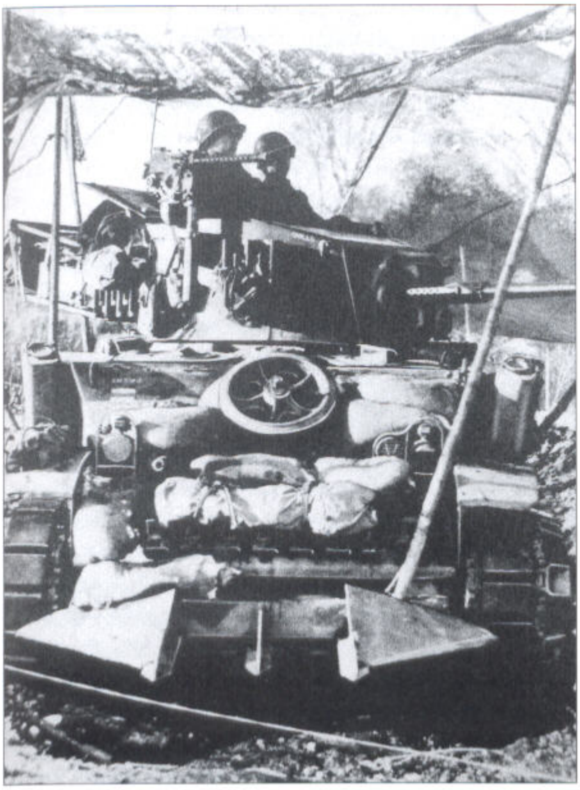
It is difficult to concentrate or relocate tanks in a combat zone, because of the considerable effort required to transport them long distances by heavy road transporter or rail wagons. Long distance travel on their own tracks over even improved roads renders a significant percentage mechanically disabled before they see combat. Tanks require a considerable support 'tail' in the form of specialized maintenance personnel, spare parts, field repair facilities, recovery vehicles, and fuel and ammunition transport.

PROTECTION & VULNERABILITIES

Tanks originated to provide a means of conveying protected weapons and their crews over obstacles and while under fire, so their armour is one of their defining advantages.

The armour on a tank was not consistently thick; typically, the thickest was found on the gun mantlet (the shield protecting the opening where the gun emerges from the turret) and other frontal parts of the turret, and on the front of the hull. This too varied: the upper glacis – the down-sloping portion of the hull front – was thicker than the lower glacis on the bottom of the nose. Next in thickness were the turret sides, followed by the forward and central portions of the hull sides, especially above the tracks. The lower hull 'inside' or 'behind' the tracks was thinner: being lower, it was difficult to hit, and was also protected to some extent by the tracks, road wheels and return rollers. The rear portions of the hull sides, the back of the hull, and the top surfaces of both hull and turret were relatively thin; so was the turret rear, though this was thicker than much of the hull side armour. The belly, except for the most forward portion, was relatively thin. Heavy armoured gratings protected the top of the engine compartment, but were vulnerable to demolition charges and incendiaries.

Regardless of the armour, tankers were quick to add additional protection from AT fire. Here a US Stuart M5A1 light tank has track links, a road wheel and sandbags fastened on the hull front; even filled 5gal water cans gave a little extra protection, and more track links are fastened to the turret sides. The toothed attachment on the bow was a locally fabricated blade to cut through Normandy hedgerow banks. Note too the 'grousers' added to the outer edge of the tracks, to increase track width and reduce ground pressure.



The construction of a tank's armour was also a factor. Homogeneous armour maintained a constant degree of hardness through its entire thickness, while hard-faced armour had a harder exterior than interior. Hulls and turrets might be manufactured by riveting or welding armour plates together, or might be cast in single pieces. Bolting and riveting was the least effective, as a hit could buckle the plates and break them loose, while simultaneously turning 'popped' rivets into projectiles. Welded armour was more effective, but cast armour was even better. The use of sloped armour increased during the war in order to deflect the strikes of AT projectiles; this greatly increased armour effectiveness, allowing thinner

armour and thus reducing weight. More attention was given to external design to reduce the number of 'shot traps' – i.e. turret overhangs and right angles in armour that allowed projectiles a purchase.

Besides a tank's integral armour, tankers often took measures to provide additional protection. Spare track sections and road wheels were attached to turret and hull, sandbags were wired to the hull, wire mesh screen or sheet metal skirts were fastened to the hull sides to lessen the effect of shaped charge ordnance – or wooden planks, to ward off magnetic hand mines.

Regardless of the thickness, type and slope of armour, a tank requires openings for crew entry, weapons, sights, vision, ventilation, external fittings, and access to the engine and other automotive components. At the very least there was a hatch over the driver's position and one or two hatches for the turret crew. There might also be escape hatches, in the turret side or rear, hull side above or behind the tracks, and sometimes in the belly; late in the war this latter was often deleted, as it made tanks more vulnerable to mines. (Contrary to popular perception, hatches could be locked from inside.) Sometimes a small hatch was provided in the turret rear or side through which to load ammunition or eject spent shell cases. Smaller pistol/sub-machine gun ports were sometimes provided in turret sides, and flare pistol ports in the turret roof. Early tanks had vision slits around the commander's cupola, in the turret sides and other positions, and a shuttered driver's view port; all these were vulnerable to concentrated small arms fire. Flare pistols could also be fired at vision ports to blind crews at night. Periscopes and bulletproof glass vision blocks came into wider use with time, but these too could be damaged by gunfire.

Early tanks possessed enough small openings that air could enter. These were very susceptible to flames, smoke and tear gas – all commonly recommended as early infantry anti-tank measures. Later tanks were better protected from these effects; protected ventilation ports were provided, often with forced air ventilation, both intake and exhaust.

A Sherman of 6th South African Armd Div crossing an Italian river. A tank's fording depth was limited, and seldom exceeded 3 feet. This could be extended by waterproofing and fording kits, as here, but these required time-consuming preparations; once prepared for deep fording the turret often could not be turned, the guns elevated, or certain hatches and ports opened without breaking waterproof seals. Water obstacles provided more of a barrier than just their depth; steep banks on either side, muddy or rocky bottoms, and marshland on adjacent banks could easily prevent a tank from crossing even a shallow water barrier.

Limitations to mobility

While tanks possessed a high degree of cross-country mobility over rough terrain and obstacles, they were limited to some degree. Among a tank's weakest points was exactly what made it a tank: its tracks, formed of separate plates linked and pinned together in a flexible belt. Mines, gunfire or obstacles could break tracks; and exceedingly rough terrain and violent manoeuvres could 'throw' a track off its guiding sprocket.

Many tanks were relatively underpowered, which affected their speed, manoeuvrability, and ability to negotiate obstacles and rough terrain. The maximum speed obtained by most tanks was 12 to 25 miles per hour. Moving such a heavy vehicle often caused the engine to overheat, whether it was air- or water-cooled. The ravages of abrasive, clogging dust were a constant problem; engine life was short, requiring frequent maintenance and replacement. Fuel consumption limited operating range, and was measured in gallons per mile rather than miles per gallon. Tanks might be powered by petrol/gasoline or diesel; petrol engines required more frequent refuelling and were more prone to catch fire, but required less maintenance. Diesel engines were more expensive to produce, but provided better power-to-weight ratios; the fuel was less combustible, gave greater range for its volume, and was cheaper.

A tank destroyer was not a tank; while built on tank chassis, their armour was generally lighter and they often had open-topped turrets. They were designed to kill tanks and not to support infantry, although they often had to perform that task – a role in which they were made vulnerable (like this US M10) by the lack of a tank's co-axial and bow machine guns. In urban fighting all AFVs suffered from the limited elevation of their guns, which restricted their ability to engage targets on the higher floors and roofs of buildings.

Rough terrain and obstacles caused more difficulty than is often appreciated. Sinking into deep mud, swampy ground or soft sand could 'belly' a tank; running the nose over tree stumps or boulders could break traction because of the low ground clearance. Tanks could easily lose their grip on ice, mud, gravel and steep inclines. Most early tanks had comparatively narrow tracks, limiting their ability to cross soft ground due to the relatively high ground pressure per square inch. Wider tracks, or 'grousers', added to the outside edge, were often provided to reduce ground pressure; but wider, heavier tracks further reduced speed, increased fuel consumption and caused more wear on the running gear.

The height of the man-made or natural obstacles that a tank could negotiate depended on the design and angle of the front of its tracks and hull; most tanks could not mount a wall much over 3 feet high. Trenches and ditches whose width was more than one-third the length of the track's 'ground footprint' could halt a tank; so could closely spaced trees of even moderate diameter. Extensive tangled barbed wire and other debris could jam running gear. Long-barrelled guns were restricted in woodland and built-up areas, where their traverse was sometimes blocked.

Armament

The main gun was mounted in a turret with a 360° traverse; elevation and depression were typically limited. Ideally the gun would be a long-barrelled high velocity weapon capable of defeating other tanks, but short-barrelled low velocity guns were often provided for the infantry support role; this was a mistake, as tanks so armed were mostly incapable of engaging enemy tanks. There was much resistance in many armies to providing improved or larger calibre guns. All sorts of tactical rationales were argued, but the real reason for using low velocity guns was to reduce costs or conserve materials. In a very few instances tanks also mounted a smaller calibre secondary gun, but the complications outweighed the advantages. Gyro-stabilization was not always provided for the gun, and this greatly reduced the ability to engage targets while

The sergeant commander of a British M3 Grant of 5 Royal Tank Regt signalling by flag in the North African desert, February 1942. Conditions were not so suitable for visual signalling on most other wartime fronts, and it obviously could not be used at night or in other conditions of limited visibility. (IWM)

moving; a tank would have to halt to aim and fire, during which time it was vulnerable. Other weaknesses affecting weapon performance were hand-operated as opposed to powered turret traverse, and relatively inefficient sighting systems.

A tank's machine guns are often discounted, but in fact they proved to be extremely valuable for engaging enemy positions, troops and soft-skin vehicles. They were even more important for protecting their own and other tanks from attacking infantry. Most tanks mounted a co-axial machine gun in the main gun mantlet. Frequently a bow machine gun was mounted in the right front hull, and another externally on the commander's cupola for air defence and ground targets. Occasionally a machine gun was mounted in the back of the turret or other unusual positions, mainly in some Russian and Japanese types.

The British and Germans employed smoke grenade dischargers on some AFVs. These were small tubes fitted outside the turret, capable of throwing phosphorus smoke grenades 20 to 100 yards, rapidly creating a dense smoke screen to conceal the tank while it withdrew or changed course. (The bursting phosphorus threw out burning particles dangerous to both attacking and supporting infantry.)

The crew environment

The greatest tactical weakness of a tank is the crew's very limited field of vision, and their complete inability to hear anything outside. Communications between tanks was critical in order to co-ordinate effective tactics. In the early days hand and flag signals were used, but these could not be employed once tanks came under fire, in forest, or in poor visibility due to night, rain, snow, fog, smoke or dust. Visual signals also required tank commanders to constantly observe unit commanders' tanks for orders. Only radios provided effective intra-tank communications. Most countries provided only sub-unit commanders' tanks with two-way radios, and line tanks with receivers. Communication with infantry was even more difficult. In most armies infantry below company level lacked portable radios, and even if they were so equipped infantry and tank radios used different frequencies. Infantry–tank co-ordination was accomplished by hand signals, coloured smoke grenades, signal flares, tracer fire, and limited verbal communication. The problem was compounded by the difficulty of simply attracting the tank commander's attention. Late in the war the Western Allies fitted some tanks with an external telephone set for communication between tank and infantry commanders, but this was never a complete solution.

The tank crew had to endure great heat, deafening noise from the engine and running gear, dizzying fumes from the engine and gun, cramped space hampered by awkward interior fittings, violent pitching and lurching during cross-country movement, poor visibility, and the ever-present fire hazard. Driving with the unwieldy steering and clutch

systems of the period was physically exhausting, and sometimes drivers and co-drivers had to be rotated at intervals. The loader had to cope with insufficient space, heavy ammunition, and the dangerous recoil of the gun. The gunner was busy acquiring targets and operating the main gun and co-axial machine gun, and in smaller tanks he sometimes had to load for himself. The commander was the busiest, having to guide the tank, determine routes, search for targets and threats, watch his commander's tank, maintain formation, and co-ordinate the crew. In some light tanks he additionally served as gunner and/or loader. Either the commander, loader or co-driver/hull machine gunner also had to man the radio.

For self protection if they were forced to abandon the tank (and were quick and lucky enough to do so, before exploding ammunition turned it into an oven), most crewmen were armed with pistols, and one or two sub-machine guns were often stowed in the tank; a supply of hand grenades was also carried to fend off infantry attacks. 'Baled out' crews were a legitimate target who routinely drew fire from enemy tanks and infantry.

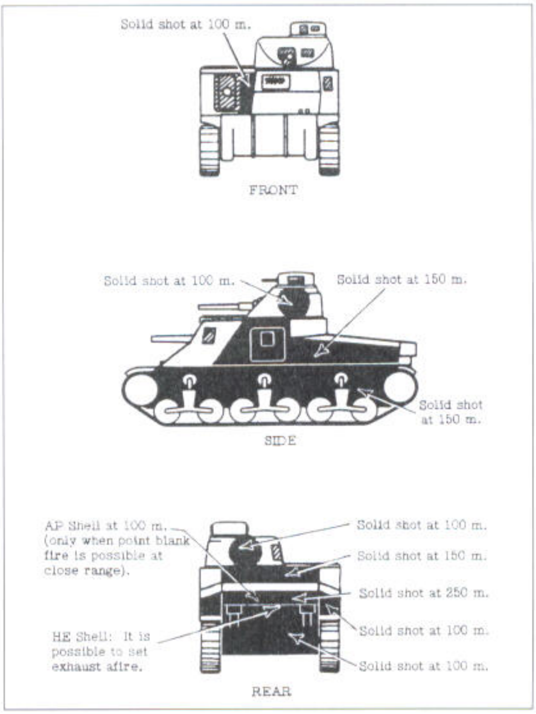
* * *

Mines, other tanks, AT guns, infantry AT weapons, artillery, ground-attack aircraft and direct infantry attack were the main causes of tank losses. Natural obstacles halted more tanks than man-made, and banal mechanical breakdowns took a high toll. Regardless of all their limitations, however, tanks were formidable weapons; they could be decisive if handled and supported effectively, and were a serious threat to infantry. A brief note on tank unit organization is necessary.

Germany and the USSR employed tank regiments with two or three battalions. The US replaced its three-battalion regiments with separate battalions attached to regimental-sized 'combat commands', although two divisions retained regiments. British Commonwealth and Japanese tank 'regiments' were of single battalion size. Most tank battalions had three or four companies, either of the same type, or occasionally with three light or medium companies and one of the opposite type. A tank company typically had three or four platoons. A platoon consisted of between three and six tanks, but four or five were common; and one to three tanks were assigned to each company headquarters. Commonwealth armies referred to their company-size units as 'squadrons' and platoon-size units as 'troops', in the cavalry tradition; their squadrons each had four three-tank troops.

Tank recognition cards

The Germans first used recognition leaflets in 1917 to depict silhouettes of enemy tanks and indicate points vulnerable to attack. Similar sheets or booklets were used by most armies in World War II to provide a means of identifying different types of AFVs by line drawings; effective aiming points might be indicated, and sometimes other vulnerable areas such as the engine, fuel tank and ammunition storage. The Germans issued four-page leaflets for each type of enemy tank, specifically for each calibre of AT/tank gun (2, 3.7, 5, 7.5 & 8.8cm), indicating the type of ammunition effective at different ranges. The leaflets were stowed in the gun's sight box; sometimes a sheet for the main type of tank the crew was fighting was taped to the gun shield beside the sight. This translated example is for the US M3 Grant tank, for a 2cm gun mounted on the PzKw II light tank. Black areas = lethal effect; crosshatched = deterrent or damaging effect; white = no effect.
The Germans often painted reminders on the inside of AT gun shields, e.g. 'Observe Carefully' or 'Be Certain' (to reduce fratricide), 'Remember Camouflage', or simply *Kaltblutig* ('cold blooded' - i.e. 'be calm and serious').



Regardless of the number of tanks assigned to a company/squadron, a company in combat would soon be reduced by combat losses and mechanical failure. Tankers preferred to operate in company formations for mutual support, firepower and shock effect. Platoons were considered the smallest practical element for combat; and the absolute minimum was for tanks to operate in pairs.

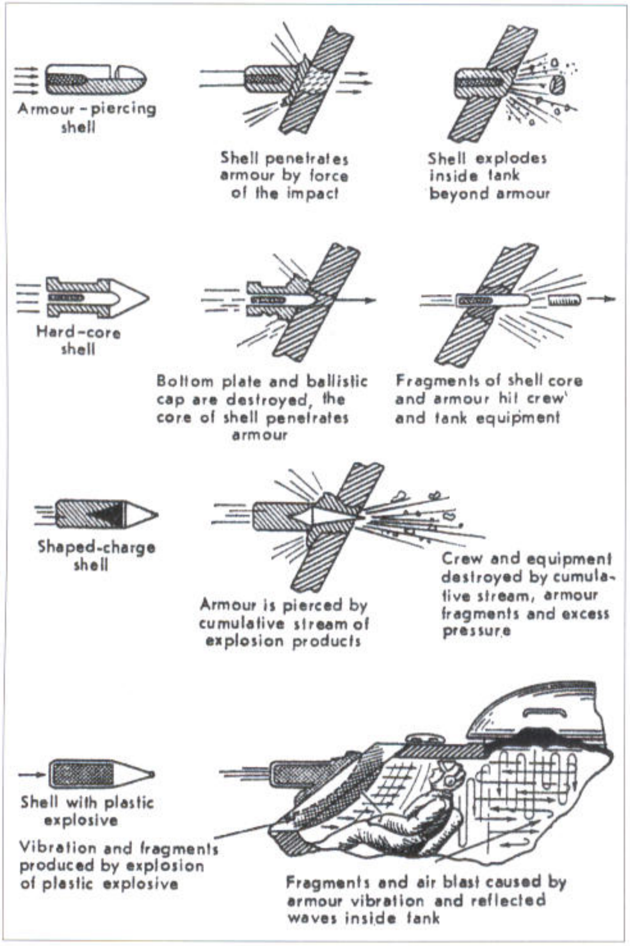
Equally important was for tanks to be accompanied by infantry – to reconnoitre and clear routes, warn of AT weapons and attacking infantry, direct tanks to bypass mines and obstacles, co-ordinate manoeuvres, identify targets and direct the tanks' fire. Accompanying infantry were essential to protect tanks from close-in attacks, especially in close terrain or built-up areas. Tanks committed without infantry, separated from infantry by enemy action, or leaving their infantry behind, were extremely vulnerable.

ANTI-TANK WEAPONS – AN OVERVIEW

At the beginning of the war most countries followed fairly similar anti-tank doctrines, varying according to the terrain of their expected areas of operation, the numbers and types of allotted AT weapons, and the expected enemy's tank capabilities. The main precepts of AT warfare included separating tanks from their supporting infantry; channelling armour into 'kill zones'; positioning AT weapons in depth; causing tanks to 'button up' (close all hatches), thus increasing their vulnerability and hampering command and control; massing AT fires; exploiting tank-restrictive terrain, man-made and natural obstacles and minefields; and blinding and screening by means of smoke.

This discussion of AT weapons is limited to those found at battalion and lower levels of infantry units. Large calibre towed and self-propelled AT guns operated by specialist units generally fall outside the remit of this book, though with isolated exceptions.

A wide variety of AT weapons existed in 1939, and during the war the search for more effective weapons arguably saw more variations of design and developmental effort than those for any other category of weapon, ranging from the mundane, to the innovative, to the frankly bizarre. Regardless of the weapon's design – be it a high velocity gun, an advanced rocket launcher, or a bomb slapped on to a tank's surface by a desperate infantryman – the aim of any AT weapon was to deliver a projectile or explosive charge capable of penetrating a tank's armour or otherwise disabling it.



This diagram translated from a Soviet manual depicts the four most common types of AT projectiles used in 1943, and their capabilities when fired at 300 yards' range. (Top to bottom:) Armour-piercing high explosive (AP-HE) Armour-piercing capped, with a penetrating core (APC) Shaped or hollow charge – high explosive anti-tank (HEAT) High explosive plastic or 'squash head' (HEP or HESH).

Armour-piercing shot

Kinetic energy is the basic means of penetrating a hard material, and this must be delivered by a high velocity gun. The simplest example is the armour-piercing (AP) shot: a solid projectile made of hardened steel with a comparatively blunt nose, though usually provided with a streamlined 'windshield' (the tip of a sharp-nosed projectile, like an arrow, will break off on impact and the mass will be deflected). AP shot relies on its speed and hardness to penetrate. All armies issued AP cartridges for their rifles and machine guns; these pre-dated tanks, having been developed in World War I to defeat snipers using steel plate shields for cover. They were ineffective against all but the lightest AFVs, since they typically penetrated only 6mm to 10mm (¼ to ½in) of armour when striking at right angles (i.e. 90°) and within 100 yards' range.

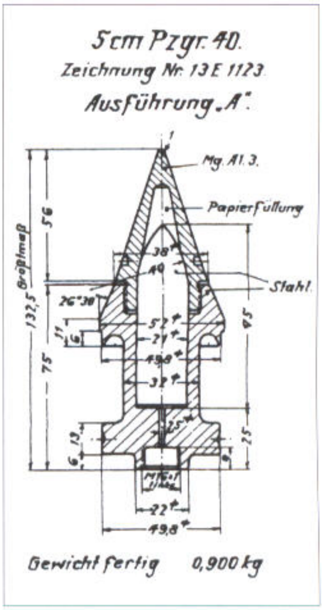
Variations on the larger AP rounds include a small high explosive (HE) or incendiary charge in the projectile's base; such AP-HE and AP-I rounds, fitted with base-detonating fuses, explode or ignite after penetrating, to cause fragmentation or scatter burning particles to ignite fuel or ammunition stored inside the tank. Armour-piercing capped (APC) is AP shot with a soft metal nose cap that 'turns' the projectile to roughly 90° when it strikes armour. Another variation is a smaller calibre hardened penetrator sheathed in a larger soft metal projectile; when it strikes armour the softer material is stripped off and the penetrator punches through. Enhancements aside, the AP round itself causes little damage to the tank other than making a hole. Most crew casualties and internal damage are caused by fragmentation from the penetrated armour and the projectile, breaking up and ricocheting around the cramped interior with lethal effect. The least desired effect is for the projectile to pass entirely through the tank and out the other side, causing minimal damage.

'Squash head' munitions

The high explosive plastic or 'squash head' (HEP or HESH) round is a plastic explosive charge contained in a thin-walled projectile with a base-detonating fuse. It relies on brute force to smack into the tank, with the pliable explosive 'squashing' out and detonating, so that the explosion sheers off fragments from the inside of the armour. If the armour is sufficiently thin the HEP round may blow a hole through it or severely buckle it. This round has the advantage of low cost, and is also useful against soft-skin vehicles, and light fortifications and buildings, since it has the same effect on concrete and masonry as on steel.

'Shaped charge' munitions

'Shaped charge' or 'hollow charge' munitions rely on the 'Monroe effect', employing an explosive charge with a cone-shaped cavity. When the open end of the cavity is placed against the target it focuses the blast on a single small point, cutting a hole. Early shaped charges had shallow cavities. During World War I a German designer improved the concept by lining the cavity with thin metal, and detonating the charge not directly against the surface but a short distance from it (a 'stand-off' of two to three times the diameter of the charge) to further focus the blast. In 1938 two Swiss engineers perfected the principle and demonstrated its use in demolition charges. A British ordnance engineer employed



Germany introduced the *Panzergranatpatrone 40* anti-armour round (Pzgr 40, or to the Allies 'AP40') in all AT and tank gun calibres; this is the head of a 5cm shell. They achieved a higher velocity than standard AP shot, with a softer steel sabot ('shoe') around a small penetrator core of hard tungsten, and an easily crushable 'wind-shield' pointed nose. Like many AP rounds they had a tracer element in the base; by tracking the tracer in flight the gunner can 'sense' if the round is a hit or miss before it strikes, and can then either correct his aim for the next shot or acquire another target. Fractions of a second can mean life or death when engaging tanks.

the concept in his design for the first shaped charge AT rifle grenade; and the first use of the shaped charge by most countries was for such munitions.

During the war an entire range of weapons were provided with shaped charge warheads; these 'high explosive anti-tank' (HEAT) munitions included hand and rifle grenades, AT and tank guns, AT rocket launchers, light field artillery shells, and hand-placed demolition charges and mines. While widely used by the US, Britain and Germany, shaped charge rounds saw limited use by the USSR, Japan and Italy. One of the main benefits of shaped charge projectiles is that they do not rely on velocity or mass to penetrate armour; such a round will achieve the same penetration at 500 yards as at 50 yards. It makes no difference if the projectile is hand-thrown or fired from a high velocity gun: while the two entirely different types of projectiles will by necessity be of different designs, if they are of the same size and internal arrangement the penetration will be the same. The projectile is comparatively light and inexpensive to make.

A US 57mm M1 AT gun in 'full battery'. The M1 had an artillery-type hand-cranked traverse rather than the shoulder traverse of the British 6-pdr from which it was copied. The M1A2 was provided with the shoulder traverse, however – a panel beside the breech allowed the gun to be swung freely by the gun layer's weight. The wavy shield edge, retained from the British design, helped distort the shield's appearance for concealment; and note the gun's low profile.

Upon impact, the projectile is detonated by a base-detonating fuse, and the metal cavity lining is transformed into a molten 'hot solid slug', which punches through armour plate at approximately 33,000ft per second. This process is usually described as the liner being 'vaporized into a plasma jet that instantly burns through armour'. This molten metal slug carries with it fragments from both the projectile and the armour itself. The hot slug and fragments ignite ammunition and fuel and kill or seriously injure anyone in their path. The entry hole is surprisingly small, its outer diameter being larger than the hole on the inside. Besides armour, shaped charges penetrate any resistant surface such as concrete, masonry, timber or even sandbags.

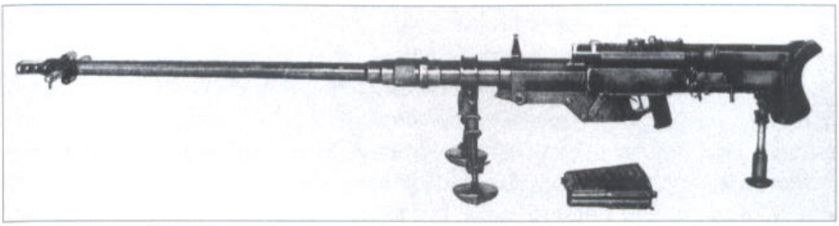
Fin-stabilized shaped charge rounds have more effective penetration than spin-stabilized projectiles; the former do not rotate, or do so at a very low rate. The high rate of spin imparted to spin-stabilized projectiles (achieved by rifling) dissipates up to three-quarters of the penetrating effect through centrifugal force. This is why rocket and rifle grenade HEAT rounds are more effective than one fired from a rifled AT gun.

The effects of shaped charge warheads can be reduced by placing heavy wire mesh or thin steel plates a short distance outside the armour plate. This causes the shaped charge to detonate short of the target and dissipates the effects of the plasma jet, resulting in little or no penetration.

OPPOSITE **Bazookas – here an M1A1, still in service in August 1944 – were not used by specialist crews; riflemen were trained to operate them, and individuals within a US rifle platoon were designated to use them in combat. More often than not tank destroyers were assigned to support infantry units, a role far different from their mission as originally envisioned – note the M10 in the background.**

Smoke munitions

Various chemical munitions were also used against tanks. Smoke-producing projectiles and grenades are a double-edged sword. White phosphorus (WP) is the most effective of several smoke-generating agents; apart from creating a dense white smoke cloud, its burning particles, scattered by a small bursting change, burn on stubbornly at 5,000°F (2,760°C). They rain down on troops in open positions, to



burn through flesh, and they stick to any surface they touch. Other types of smoke only burn upon impact and do not produce casualties. While WP does not inflict appreciable damage on tanks, smoke is a useful anti-tank aid; dense smoke screens blind tanks, causing disorientation and breaking up formations, and conceal the approach of close-in infantry attacks. Equally, smoke also screens the movement of tanks, conceals them, and prevents enemy gunners from effectively engaging them. Hand-placed smoke pots, smoke candles and smoke grenades were also used by wartime armies.

Anti-tank rifles were too heavy and awkward for infantrymen, but at the beginning of the war there were few other weapons available to them for AT defence. This is a Swedish-made Solothurn 20mm s18-1100; it weighed 54.7kg (103lb), and was 2.16m (7ft) long. It had semi-automatic feed from a 5-round magazine, and could penetrate 15mm of armour at 300 yards. This weapon was used by Italy, Hungary, Romania, the Netherlands, and to some extent by Germany.

Anti-tank guns

Among all the many weapons developed, these remained the most widely used means of attacking tanks. At the beginning of the war most countries fielded a 37mm AT gun with fairly common characteristics. A great deal of development had taken place in the 1930s as improvements in tanks were noted. These guns were mounted on two-wheel carriages and capable of towing by a light truck; most countries had recognized the necessity of providing AT guns with motorized mobility in order to get them into position, withdraw them, and reposition them rapidly. Nevertheless, since most weighed only several hundred pounds they could be manhandled for short distances. Typically they had a protective shield, a split trail mounting, and could be traversed rapidly.

These small guns were basically obsolescent in 1939, and obsolete by 1941. They sometimes remained in use until the war's end out of necessity, though mostly in supplementary roles; all were provided with HE rounds for use against other targets. Introducing improved ammunition sometimes extended their life, but the small calibre guns were simply incapable of punching through the increasingly heavy tank armour encountered from the mid-war years.

The development of larger calibre AT guns had begun in most countries before the war, but few had been fielded. Medium calibre weapons in the 45mm to 57mm range soon began to appear, and largely replaced the 37mm class, of which most were simply scaled-up versions. (Calibre alone can be misleading: e.g. the

British 'pounder' designation system

During World War II some British weapons were designated by a 'pound' system rather than by calibre. This was a traditional system based on projectile weight, dating back to the days of black powder and solid cannonballs; applied to modern artillery, these designations bore only an approximate relationship to the actual weight of the projectile. The metric and inch calibres of various British weapons designated in the 'pounder' series were as follows:

2-pdr AT gun	40mm	1.57in
6-pdr AT gun	57mm	2.24in
17-pdr AT gun	76.2mm	3in
18-pdr field gun	84mm	3.33in
25-pdr gun-howitzer	87.6mm	3.45in

performance of underpowered Japanese and Italian 47mm guns did not compare with that of their contemporaries.) Although they too soon became obsolescent, medium calibre guns generally remained in use by infantry units. The shortage of AT guns was so dire that many armies employed anything they could get their hands on, including captured weapons and obsolete light artillery pieces modified for the AT role. Still larger calibre weapons in the 75mm range were developed; these were usually assigned to divisional and higher level AT units, but some found their way into infantry AT units.

Anti-tank guns had their limitations. Even the light pieces were heavy, and while the crew could manhandle them into and out of position, this was by no means rapid. The 37mm guns were small enough and possessed a sufficiently low profile that they could be concealed easily, and existing cover was often employed. As the guns became larger they required a vehicle for positioning, and were more difficult to conceal – crucial to the effectiveness and survivability of an AT gun. Considerable effort was required to dig in these larger pieces, and they were difficult to withdraw and reposition rapidly. The late-war behemoths fielded by Germany (8.8cm) and the USSR (100mm) were verging on impractical in the role: their size and weight had become a liability negating their destructiveness. On the plus side, AT guns used well-proven artillery technology, they were reliable, and they were accurate at comparatively long ranges.

Anti-tank guns organic to infantry units were manned by specially trained infantrymen rather than artillerymen or specialist AT troops. Typically an early infantry battalion had a platoon of three to six 37mm guns, while the multi-battalion infantry regiment/brigade had an AT company with six to 12 guns. Later in the war the battalion AT platoon was often deleted, having been replaced by other weapons at company level. In some armies it was retained with 37mm guns mainly in the infantry support role. The regimental/brigade AT company usually received larger calibre guns.

Other infantry weapons and munitions

The **anti-tank rifle** was in widespread use but essentially obsolete in 1939. The Germans had fielded a 13.2mm AT rifle late in World War I, and development had been rapid in the mid-1930s. Most countries employed an AT rifle when the war began, with the exception of America, which relied on its .50cal heavy machine gun. The calibre range of AT rifles varied between 7.92mm and 20mm. These weapons were heavy, weighing from 30-plus to over 100 pounds, and were very awkward to handle, requiring two or even three men to transport the weapon and its ammunition. They measured from 5ft to 7ft in length, and were supported by a bipod; the longer ones sometimes had removable barrels. They were actually more awkward to move than many machine guns, and their weight and bulkiness was a frequent cause of complaint.

For their weight and size their armour penetration was marginal, usually only about half an inch (13mm) at 200 to 300 yards. Some performed better, such as the 14.5mm and 20mm, but were still far from effective even against 1939 tanks. Because of their weight most did not have excessive recoil, but the muzzle blast could be uncomfortable. Their designs varied greatly, including magazine-fed or single-shot, semi-automatic or bolt-action. By 1941/42 they were largely withdrawn; only the Soviet Red Army kept them in widespread use, but most countries replaced them with some more man-portable weapon.

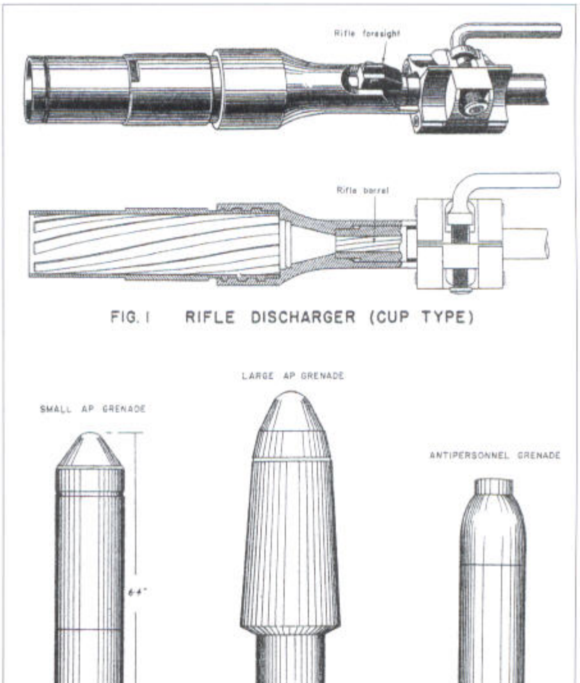
The development of bazooka-type **anti-tank rocket launchers** began in 1941. These man-portable, shoulder-fired weapons projected a HEAT warhead; most were reloadable, but the revolutionary German *Panzerfaust* was a single-shot disposable weapon. Their light weight made them easily portable by infantrymen on the battlefield, and they were quick and inexpensive to produce in large numbers. Since the HEAT warhead was more effective as a fin-stabilized projectile, this provided an ideal match between launcher and warhead. They were also effective in smashing through light fortifications.

The shoulder-fired AT rocket launcher was an answer to the infantryman's prayers, but early weapons did have their problems. Their range was short – less than 200 yards, and often under half that; the reliability of the rockets, both in launch ignition and detonation on the target, was sometimes wanting; and the design of early warheads was far from optimum. This class of weapons suffered (and still does) from tactical limitations. Rocket launchers need an unobstructed area to the rear for their considerable back-blast; they generate a noticeable firing signature of smoke and dust (partly countered by their ease of relocating); and they cannot be fired from within enclosed spaces – such as a room of a conventional house – because of the back-blast overpressure.

'Recoilless rifles' saw only limited use. The Germans pioneered the development of these light guns, which exploited the same principal of equalizing the recoil by means of a simultaneous back-blast, but employed a breech-loaded shell with a perforated propellant case rather than a self-propelled rocket. The US fielded a small number of recoilless rifles at the end of the war. While both nations provided HEAT rounds, because they were spin-stabilized these were only marginal AT weapons; the German design was slightly more effective as it used standard artillery HEAT projectiles with a slower spin.

Most countries developed **rifle-launched anti-tank grenades** to give any infantryman at least a halfway effective means of combating tanks. Being fin-stabilized they were somewhat effective for delivering a shaped charge, but the 1940 cone designs, light explosive charges, and often inferior fusing gave them poor penetration and

In the early 1940s most countries adopted a shaped charge rifle-launched AT grenade of some type; cup dischargers were adopted by Germany, Britain and Japan. Fig.1 is the rifled German 30mm *Schiessbecher* adopted in 1942, capable of firing 30mm AT (Fig.2), over-calibre 40mm AT (Fig.3), and 30mm high explosive grenades (Fig.4).



reliability. Effective range was seldom over 100 yards, and that only against light armour. The use of rifle grenades required a special launching device fitted to the muzzle and special launching cartridges. One or more launchers were provided to rifle squads/sections; these could also launch anti-personnel, smoke and signal grenades.

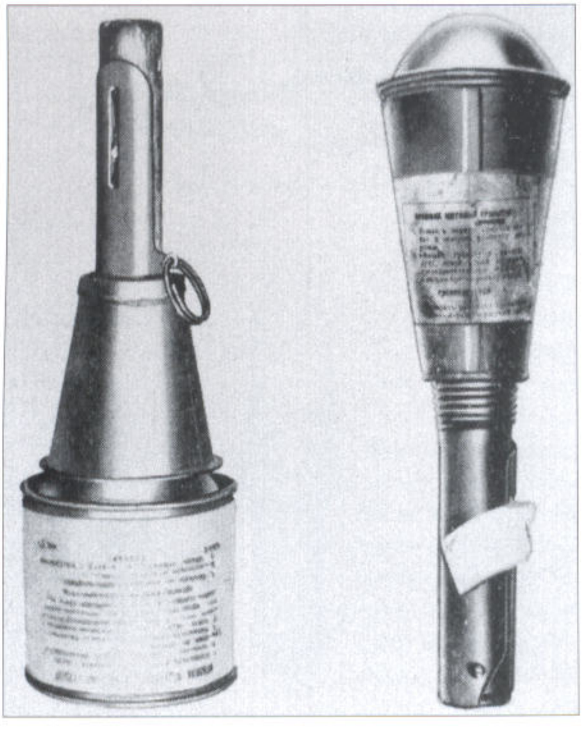
There were three types of rifle grenade systems. The discharger cup type required a cup-like device attached to the rifle's muzzle in which the grenade was inserted. Their disadvantage was that the cup blocked the use of rifle sights for regular firing while it was fitted. The spigot type featured a tube attached to the muzzle; the grenade had a hollow tailboom which slid over the tube. The rod type grenade, dating from before World War I, was soon abandoned. The grenade was fitted to a long metal rod inserted into the muzzle; it required no special launcher, but would eventually damage the bore. Most grenades had to be fired with the rifle's butt on the ground and the barrel angled at the necessary range elevation. The grenades' heavy weight caused tremendous recoil that would damage a rifle after repeated use – to say nothing of the shoulder of any grenadier unwise enough to try firing it with the conventional grip. For the direct fire required by some AT grenades the rifle stock was placed under the arm and clamped tightly to the side of the torso with the elbow.

Anti-tank hand grenades were developed before the war, but were essentially weapons of last resort. Most relied on a simple HE charge to penetrate light armour or break a track. Because of their necessarily small size they were none too effective, especially against all but the lightest tanks after 1941. They were most effective against tracks, and upper surfaces such as turret tops and engine decks. Britain and the USSR were the main producers of AT hand grenades; the US did not bother with their development, and Japan only fielded some inefficient designs late in the war. To be effective some stabilizing system was necessary to ensure the grenade struck the target in the right attitude to maximize the blast. They were larger and heavier than standard grenades, and so could be thrown only about 20 to 30 yards.

A larger version of the AT hand grenade was the **hand mine**. These were larger explosive charges hand-placed by very bold infantrymen – in reality, virtual suicide weapons. Most had shaped charges and were attached to the tank by magnets; the mine was slapped on to the tank, with a delay fuse that left barely sufficient time for the attacker to dive for cover. Others were hand-thrown and impact-detonated, but because of their weight their range was as short as 10 to 15 yards. In the hands of determined men in close terrain they offered a considerable threat, however, forcing tank crews to take drastic protective measures.

Among **chemical munitions**, smoke grenades, smoke candles and smoke pots were employed by infantry in close-in attacks. Early in the war

Anti-tank hand grenades were heavy, due to the necessarily large explosive charge, and this gave them a short range. These are the flat-nosed Soviet RPG-42 (left) and domed RPG-6 (right) of 1944, with shaped charges penetrating 75mm and 100mm of armour respectively. To ensure that they struck the target at the necessary angle, stabilizing tail streamers deployed when they were thrown (see Plate F).



some store was also placed in tear gas grenades; the idea was to bombard a tank with irritant gas grenades so that the fumes sucked into the tank's ventilation system would blind or drive out the crew. The Japanese developed a toxic gas grenade to be employed in the same manner. In reality smoke and gas grenades were relatively ineffective, as the tank merely drove out of the small area affected, often before a troublesome amount of gas entered the tank.

The first **anti-tank mines** were buried artillery shells used in World War I. Extensive development of purpose-made AT mines was pursued in the late 1920s/early 1930s and continued throughout the war. During World War II all armies laid millions of mines on all fronts. All combatants in North Africa created vast minefields because of the lack of natural defences and obstacles; and the Japanese made increasing use of mines as the Pacific War progressed.

Typically, AT mines were pressure-activated by a tank's crushing weight; if stepped on by a soldier they would not normally detonate. Most mines would blow off a track, but the heavier models could cause substantial damage. The layout, density, and location of minefields varied greatly. Anti-personnel mines were routinely intermixed with anti-tank mines to hamper infantry and engineers attempting to clear lanes for the tanks, and booby-trapping mines to hinder clearance was common. Minefields were tied into natural obstacles, laid on likely avenues of approach and often in patterns that would lead tanks into the sights of AT guns; the use of dummy minefields alongside real ones multiplied these effects.[2]

Like any obstacle, a minefield – whether a few mines buried at a road intersection, or multiple belts of thousands of mines – was worthless unless covered by observation and fire. If effectively sited, camouflaged and covered by fire, they could halt or at least slow a tank advance. Once the defenders were driven away it was a relatively straightforward matter (though seldom without bloody cost) to clear routes through minefields which had taken much time and effort to lay. The harassing and delaying effect of a small number of mines laid at wisely chosen points could be more effective than large minefields.

A wide and imaginative variety of **expedient anti-tank weapons** were employed. Regardless of how ingenious or effective these last-resort weapons may have appeared, and how thoroughly troops were trained in their use, any army forced to employ them was in desperate straits.

Zimmerit

The Soviets occasionally plastered a thin layer of textured concrete over their tanks to hamper the attachment of German magnetic hand mines. In case the Red Army developed a magnetic AT hand mine similar to their own, in December 1943 the Germans began applying *Zimmerit* 'anti-magnetic plaster' on the production lines of new PzKw V and VI tanks, heavy assault guns, and some PzKw IV tanks and lighter assault guns. (The Red Army never did field such a weapon, although they did use captured German examples.) *Zimmerit* was a magnetic-insulating putty, not truly 'anti-magnetic', developed by Chemische Werke Zimmer GmbH and made of 40 per cent barium sulphate, 25 per cent polyvinyl acetate, 15 per cent dark yellow pigment, 10 per cent zinc sulphate and 10 per cent sawdust. It was applied by hand in a first 5mm layer, and four hours later a textured 3mm coat was added with a spatula, and dried with a blowtorch. The ridged patterns made it more difficult to attach magnetic and 'sticky' grenades. It was not supposed to be applied to the turret, engine deck or track skirts where it would be worn off by crew traffic, but in fact it was commonly seen on these areas.

Zimmerit was ordered discontinued on 9 September 1944 because it was rumoured that gunfire could set it alight; this was found to be untrue, and the plaster was not removed, but its factory application was not restarted.

2 See also Elite 122, *World War II Infantry Tactics: Company & Battalion*

In North Africa, a British ordnance disposal engineer poses with a German Teller AT mine attached (for the photographer's benefit, unconvincingly, with a long white string from the handle) to an anti-personnel S-Mine ('Bouncing Betty') rigged to kill mine clearers. In reality they would be coupled by a short wire to a well in the underside of the AT mine. The TMi 35 held 11lb of TNT, and was set off by pressures of 420lb on the centre but only 175lb at the edges.

Most required direct attack by a soldier or at least an attack delivered at very close range, demanding a high degree of exposure and a slim chance of escape. In order to succeed the attacker required great courage, a well-chosen position, a stealthy approach, effective covering fire, absence of enemy infantry, and no small measure of luck; in the 'invasion scare' summer of 1940 a British Army manual on such tactics frankly compared the risks with 'tiger shooting on foot'. Nevertheless, training was widespread and serious; in 1940–41 such methods were often all that the British or Soviet infantryman had. Examples of expedient weapons included:

Satchel charges 10lb–20lb explosive charges packed in a haversack with a short time fuse, thrown on the engine deck, into the tracks, or jammed under a turret overhang. A variation was the pole charge, a demolition charge on a 4ft–6ft pole, allowing it to be placed on a vulnerable spot.

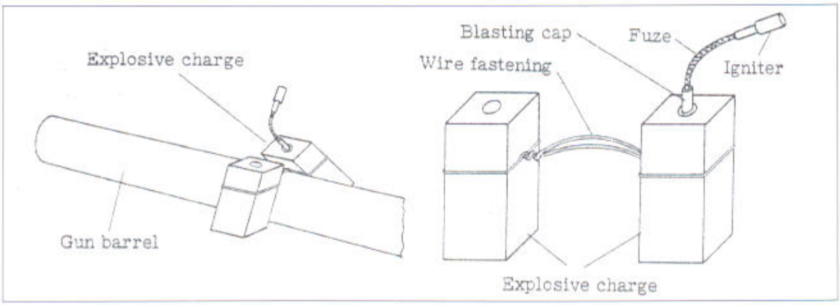
Concentrated charges Bundle of about six hand grenades or small demolition charges wired together with a central detonator, and usually a handle. Employed in the same way as satchel charges. A single grenade might also be shoved down a gun barrel.

Double charges Two demolition charges linked by wire and thrown to tangle around a gun barrel. Smoke grenades were used similarly, in the hope of blinding gunners.

AT mines Hand-delivered mines placed directly in front of a track, or thrown into the tracks.

Fire bombs Large petrol/gasoline cans (5gal/20l) with incendiary or smoke grenades attached for detonation, and thrown or dropped on to a tank's engine deck.

'Molotov cocktails' Glass bottles filled with petrol/gasoline and often enhanced with oil, rubber, tar, phosphorus etc. to make it burn longer and hotter and adhere to the tank, or to cause more smoke to blind the crew. A rag stuffed in the bottle neck was lit and the bottle thrown at the tank, preferably at vision ports, hatches, or engine compartments; some were provided with self-ignition devices. Results were often disappointing because of the small amount of fuel, and later tanks were better sealed. Another method was breaking numerous fuel-filled bottles on a tank and igniting it with flares, tracers or smoke grenades.



Expedient anti-tank weapons – i.e. those fabricated in the field by soldiers adapting available munitions and materials – took many forms. This is a German double charge, comprising two demolition charges with a short delay fuse and igniter, connected by a short length of wire; thrown over a tank gun barrel, it will disable the weapon. Most expedient weapons required a dangerously close-in attack.

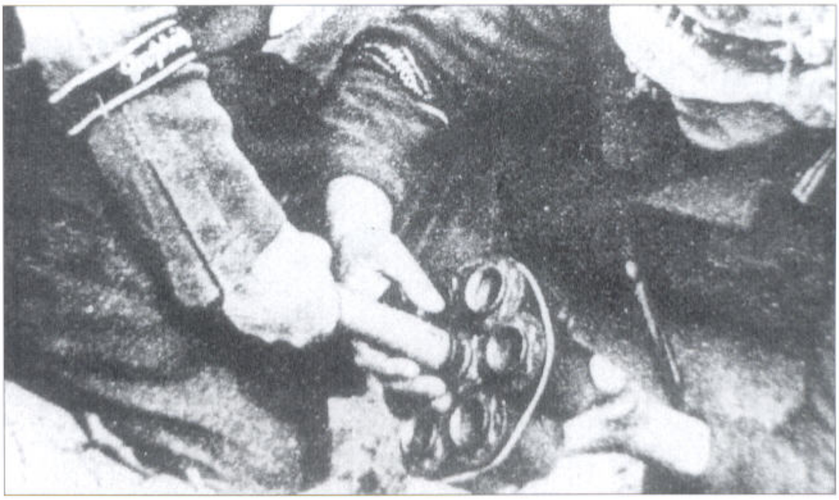
'Daisy chains' AT mines fastened together along a rope or plank, concealed beside a road and pulled across in front of a tank by a hidden soldier.

Various mechanical means of attacking tanks were suggested; some of these may have worked on early war light tanks, but against larger types they had little effect. It was recommended that a steel bar, pipe, wooden beam or even a rifle be wedged into the running gear to jam the tracks. Battering machine gun barrels with a bar, hammering on glass vision ports and periscopes, driving wedges into turret rings, forcing open hatches with crowbars, covering vision ports and periscopes with mud, burning blankets or overcoats, and similar acts of physical mayhem were measures of desperation. These, like some of the improvised munitions, were born of real experience in such conflicts as the Spanish Civil War (1936–39); but against the heavier tanks of later years they usually accomplished little, and were often fatal to those who tried them.

Field artillery and mortars are often said to be ineffective against armour. While it is true that long range indirect fire had little effect on tanks (a direct hit being rare), it did have the benefit of separating the infantry from tanks and forcing the unit to deploy into dispersed formations early in an action. Near misses only caused superficial damage. (These limitations did not apply in some exceptional cases such as the very heavy naval gunfire concentrations occasionally available to the Allied armies in Sicily and Normandy.) Concentrated artillery could destroy light tanks, however, and this was accomplished in several instances against Japanese and Italian armour. Artillery and mortars could lay smoke on tank formations, though this had the disadvantage of obscuring targets for friendly AT guns; often smoke was dropped only on the rear two-thirds of a tank formation, still allowing gunners to target the lead tanks.

In an emergency, light field artillery of up to 105mm could engage tanks with direct fire, and AP or HEAT rounds were often available for field pieces. Most were marginal in this role because of inadequate sights and slow traverse. Infantry guns – i.e. light, simplified artillery pieces manned by infantrymen – were used by some armies as fire support weapons, and some were provided with HEAT rounds, but they were ill suited as AT weapons for the same reasons.

Most **anti-aircraft guns** were provided with AP ammunition, and possessed a high rate of fire and rapid traverse. They took time to emplace, though most could be fired at ground targets while still mounted on their travelling carriage. Most AA guns were large and their high profile made them difficult to conceal – essential for a weapon engaging tanks. Some 20mm and 37/40mm AA cannon could be effective against light tanks. The German



Soldiers of the 'Grossdeutschland' Division prepare a concentrated charge with seven stick grenades. Such a charge might break a track, damage an engine if thrown on the rear deck, or penetrate lighter armour over a hatch or if jammed under a turret overhang. The concussion was reportedly enough to temporarily stun a tank crew.

This Soviet 76.2mm ZiS-3 was the standard divisional light field artillery piece from 1942. The Red Army required field artillery to be capable of engaging tanks effectively, and the ZiS-3 proved well adapted to this role; it is often considered as more an AT weapon than a field gun.

use of 8.8cm Flak guns in the AT role is well known. The round was devastating to tanks and the weapon was extremely accurate and long-ranged, but its large size and the time and labour it took to emplace was an impediment. Few other countries employed their large calibre AA guns in a similar manner, although the Soviets used their 85mm gun against armour at least as much as the Germans.

EVOLUTION OF ANTI-TANK TACTICS

1939–42

The broadly similar anti-tank doctrines followed by all armies in 1939 were based on very little practical experience. The few pre-war conflicts in which tanks were employed (Spanish Civil War, Italian conquest of Ethiopia) provided few viable lessons; only small numbers of light tanks were used, in relatively low level conflicts against forces with few if any AT weapons. These episodes gave little warning of the imminent large scale operations by mass formations of combined arms. Peacetime manoeuvres often failed either to validate or challenge doctrine, as they seldom accurately portrayed the actions of opposing armour forces.

As already mentioned, there were two schools of thought on the likely employment of armour: one foresaw massed armour plunging through the front lines and deep into the enemy's rear, the other the parcelling out of the available tanks to support the advance of the infantry. In fact both concepts were valid, but money-strapped armies tried to skimp and tended to restrict themselves. The Germans, for example, while proponents of the deep armoured thrust by massed tanks supported by mobile infantry and aircraft, also specified that PzKw IV tanks were to advance no more than 100 yards beyond the infantry and were to support the foot troops with machine gun fire.

The infantry anti-tank tactics taught in the different armies varied in detail because of local factors, but there were two broad forms of AT defence:

Passive defence included patrols and outposts to warn of approaching armour, AT obstacles and minefields, incorporation of natural obstacles into the defence, selection of defensive sectors that hindered armour and reinforced the defence, and camouflage.

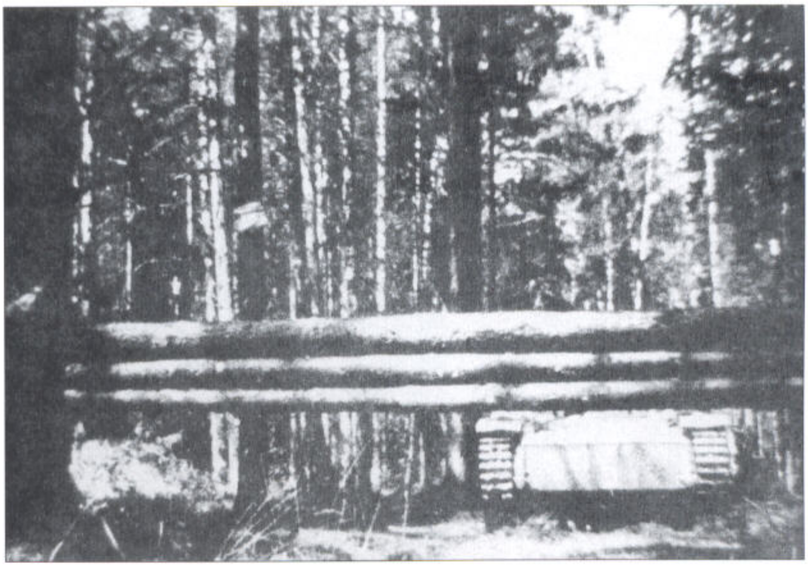
Active defence combined the skilful selection of AT weapon positions and fire zones, deployment of AT weapons, tank-hunter teams, and the use of AT reserves and counter-attack forces.

Because of the mobility of tanks and the comparatively static nature of infantry AT tactics, these are normally thought of as defensive – 'Tanks conquer, infantry holds' (J.F.C.Fuller). This is largely true; however, some degree of offensive measures could be conducted against armoured forces by even the early self-propelled AT guns, typically mounted on obsolescent tank chassis or trucks. The infantry itself, especially if limited to movement on foot, had very limited offensive capabilities against armour. Armoured or motorized infantry were not much better as their transport had little or no armour, possessed less cross-country mobility than tanks, and had few weapons capable of engaging tanks at long ranges. Tank-hunter teams could not truly be considered offensive because they had limited mobility, could cover only short distances, and their small-scale operations were usually conducted in a unit's defensive sector; they were thus basically defensive.

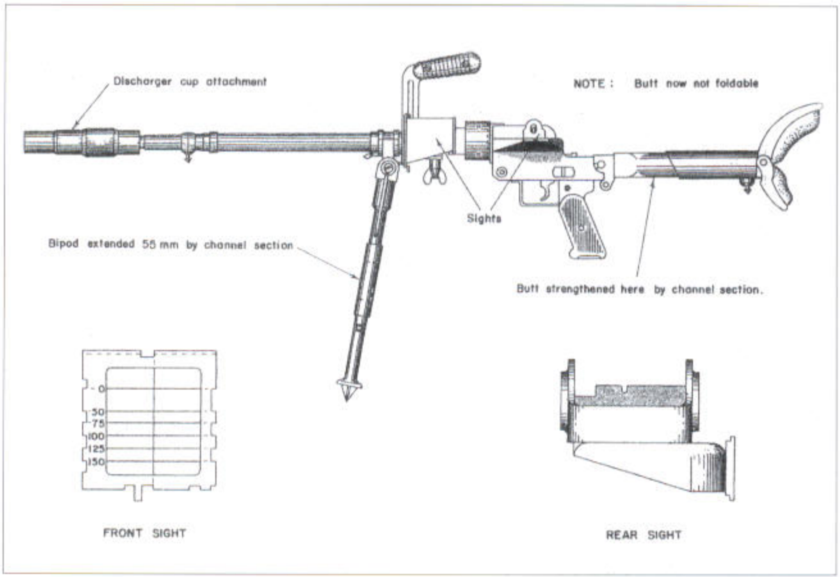
The following discussion is generic; the reader should keep in mind that each country's tactics varied to some extent, and these differences are addressed in the next chapter.

Anti-tank defensive measures were incorporated into the routine establishment of a defence. The extent of armour employed by the enemy, known enemy armour tactics, the number and types of available AT weapons, and terrain were the determining factors. An infantry regiment (or British Commonwealth brigade), regardless of nationality, typically deployed defensively with two battalions forward and one in reserve. Each battalion had two rifle companies in the line and one in reserve; the same applied to each company's rifle platoons. This meant that one-third of any echelon's sub-units were in reserve positions, and this depth of defence was essential to AT defence. The deployment of AT weapons depended very much upon the actions and disposition of the infantry units they supported, and a high degree of co-ordination and co-operation were required.

When a division established a defence the divisional reconnaissance unit and elements detached from the reserve regiment were deployed forward as a screen to protect the units preparing defences. The screening force kept enemy patrols at a distance, observed enemy activity, prevented surprise attacks, warned of the enemy's approach, and engaged the enemy if he advanced. To prevent surprise attacks by armour, AT guns from the regimental or divisional AT unit might reinforce the screening force. Once the main defences were



Anti-tank obstacles took many forms, and to be effective it was necessary to keep them under observation and fire. This Soviet roadblock is excellently designed, being tied into the tank-proof terrain of dense forest. Raising it to turret height prevents the tank from climbing it or breaking through with the force of its hull. It prevents the tank from firing down the road, since it masks the main gun; allows the defenders to fire at the weaker lower hull; and denies cover to accompanying infantry.



German PzB 39 AT rifles were modified in 1943 into the *Granatbüchse 39* AT grenade-launching rifle. Using a special propellant cartridge, it could fire the 46mm and 61mm AT rifle grenades up to 150 yards. The GrB 39 was issued three to a rifle company, like previous AT rifles. Its distribution was not wide, since the superior *Panzerschreck* and *Panzerfaust* rocket launchers were issued soon afterwards.

established part of the screening force was withdrawn, but some remained, along with some AT weapons depending on the tank threat. Each regiment and battalion in the main line of resistance placed its own screen forward in the form of outposts, observation and listening posts, and security patrols. Anti-tank guns might be deployed with these elements if there was a high armour threat, but early in the war there were few weapons available even to arm the main positions.

Ideally an 'anti-tank obstacle' fronted the main positions. This could be a minefield, tank ditch, natural obstacle (river, swamp, gully) or other tank-restrictive terrain, or simply point obstacles such as AT barricades or clusters of mines e.g. at intersections and chokepoints, or blown bridges. Shortage of time and resources often prevented the preparation of extensive obstacle systems.

Infantry battalions typically had two to six AT guns; these would be attached to rifle companies depending on tank avenues of approach, and not necessarily equally distributed between companies. As depth was important to AT defence – it was accepted that at least some tanks would invariably penetrate the main line – some of the guns might be attached to the reserve company. Anti-tank rifles, organic to battalions or companies, were usually allocated to rifle platoons. These were most effectively employed with multiple rifles engaging a single tank. Great store was placed in hand and rifle grenades, hand mines, and expedient weapons, since little else was then available to rifle platoons.

Defensive positions were placed well inside any woods rather than on the edges, since this prevented direct fire from tank guns and artillery being brought to bear on positions; it also restricted tank movement, and provided concealment for AT weapons and tank-hunter teams. Fighting positions were dug deep to allow soldiers to crouch in the bottom with 2ft of overhead clearance to protect against a tank's crushing action. The same applied to crew-served weapon positions, with narrow slit trenches dug to the sides as crew refuges from overrunning tanks.

A key to a successful defence – or at least to preventing a rout – was for infantrymen to be trained in the vulnerabilities and limitations of tanks. Confidence-building training was essential: soldiers might be made to lie on the ground between its tracks, or squat in foxholes, as a tank was driven over them. They were instructed that when tanks approached they had to remain hidden until the last moment; the closer the tank was, the safer they were, and if they waited to move out of the

way until they were inside the tank's blind zone they ran little risk of being machine-gunned. They could then attack, if close-attack weapons were available, or remain concealed until the tank passed and engage the accompanying infantry.

Some of the regimental AT company's guns might reinforce the forward companies; more often they were held in reserve, either positioned to cover likely tank avenues into the rear, or ready to move into position to block a breakthrough.

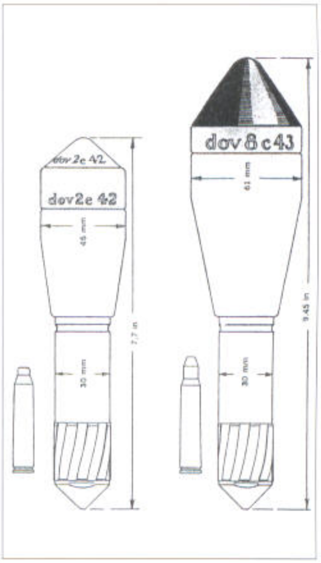
Early doctrine often called for tanks to be engaged at the weapons' maximum range. Artillery would take the enemy formation under fire at maximum range to inflict casualties on the accompanying infantry, and force tanks to assume a battle formation early, thus slowing their advance. Early in the war it was learned that it was more effective to wait until tanks were within a few hundred yards – in effect, springing an ambush – and this proved to be effective even in the North African desert. Rather than forewarning the advancing tanks with missed shots, which allowed them to take evasive manoeuvres, it was better to ensure hits at relatively close range. Mortars and machine guns would target the infantry and attempt to separate them from the tanks.

The AT guns positioned further back would engage tanks penetrating the forward positions, and if necessary the regimental reserve AT guns would go into action. Infantrymen in small teams were to take on scattered tanks with close-attack weapons, especially in forested, built-up and other close terrain. Some of the divisional AT battalion's guns might be attached to forward regiments, but most were held in reserve to block penetrations. Early in the war few if any tank units were available for attachment to divisions to serve as a counter-attack force.

In the attack, AT sub-units would accompany attacking units, usually following somewhat to the rear. They were to go into action if enemy tanks attacked the column; they might be called forward for direct fire on pillboxes, and to cover tank approaches on the flanks.

BELOW LEFT **The 30mm *Schiessbecher* cup-type grenade discharger introduced in 1942 for the Kar98k rifle could launch 30mm, 40mm, 46mm and 61mm AT rifle grenades *(Gewehr Panzergranate)*, as well as anti-personnel and various pyrotechnic and special purpose rounds. Though generally superseded by the *Panzerfaust*, these grenades remained in use until the end of the war.**

BELOW **The 46mm GPzgr 46 and 61mm GPzgr 61, for use with the *Schiessbecher* cup discharger. Their special propellant cartridges are pictured with them. Unlike most armies, which used a common launcher cartridge irrespective of the projectile, the Germans had a special cartridge for each model.**



1943–45

By 1942/43 the nature of anti-tank warfare had changed in many respects. Armour was employed in smaller scale as well as mass operations, and more frequently to support infantry, both in the attack and defence. Self-propelled assault guns were also more common on the battlefield.

Conventional AT guns were being upgraded to medium and large calibres, but improvements in tank design, armour, firepower and mobility outpaced the appearance on the field of adequate AT guns. 'Quick fixes' were common, with existing tank and AA guns mounted on AT gun carriages. Anti-tank rifles were falling from use, and in the US and later the German armies they began to be replaced by shoulder-fired rocket launchers. The British Commonwealth armies went down their own cul-de-sac (see below); and the USSR and Japan fielded nothing comparable. These highly portable weapons provided the infantry with the protection they needed, and led to new small unit AT tactics. They did not replace conventional AT guns, being considered supplementary weapons of opportunity; yet although their range and lethality were limited, they went a long way to transform the tank/infantry balance in the latter's favour, particularly in the West in 1944/45. The importance of close-attack weapons such as hand mines and AT rifle grenades did not diminish, with some countries fielding new designs.

It was realized that effective AT tactics required mobility equal to that of tanks, and more AT guns were mounted on full-tracked chassis; in a logical conclusion, it was also realized that the best tank-killers were other tanks. The necessity of making AT defences as deep as possible, maintaining mobile AT reserves, and utilizing tanks and dedicated tank destroyers was appreciated. While warfare had become more mobile, when time permitted an army in the defence prepared strong AT positions protected by extensive obstacle systems and minefields. The Red Army made extensive use of AT strongpoints, as did the Wehrmacht after the tide of success turned. More artillery was provided with AT ammunition, as were light AA guns.

After 1943 large German tank offensives were seldom seen, and only occasionally possible after major efforts to mass forces; the Japanese never employed armour on a large scale. The Allies' ability to produce tanks and field large armour formations increased. Because Axis tank attacks largely ceased apart from small scale operations and counter-attacks, the importance of small unit AT weapons and tactics increased. Because of the ability of tanks to penetrate deeply, even in local counter-attacks, the need to provide artillery units and other rear elements with AT protection was realized.

Tank-hunter teams

Most armies employed tank-hunter teams, and their use increased as the war progressed and more lethal portable AT weapons became available. Their organization was usually left up to individual units, though some experiments had been undertaken and recommendations were made. Units often developed their own tactics, and the terrain remained a governing factor. A hunter team might consist of anything between four and 12 men, with six to eight being typical, led by a junior NCO. A two to four-man attack element were armed with a stand-off weapon such as

The ultimate mobility for an infantry AT weapon was to be portable by an infantryman over any terrain. In this staged shot a US bazooka crew 'engage' a Panther PzKw V Ausf A with the 2.36in M1A1 rocket launcher, whose light weight and handy size made it easy to manoeuvre into a favourable firing position – unlike that chosen by this photographer for his reconstructed drama: facing the Panther's massive, sloped frontal armour, and inviting fire from its co-axial and bow machine guns.

an AT rifle or shoulder-fired rocket launcher, or close-attack weapons such as AT hand mines and grenades. Covering elements of two to four riflemen armed with hand, rifle and smoke grenades backed up the attack element, protecting them against accompanying enemy infantry. Often a two-man automatic rifle or light machine gun team was included for support.

Hunter teams were deployed forward of the main line of resistance, especially in close terrain, to ambush advancing tanks. Other teams were held in readiness by front line and immediate reserve sub-units to attack penetrating tanks, and others could be held deeper in the rear to ambush or intercept tanks. They were especially useful in forests and built-up areas where good cover and concealment were available, and where tanks were restricted to predictable routes and forced to move slowly. Ideally teams would be co-ordinated with other friendly elements, but the nature of combat and the scarcity of tactical radios often precluded this. Hunter teams might also be used offensively, by infiltrating enemy lines and attacking tank 'laagers' and assembly areas.

Ideally a hunter team would ambush a tank – let it come to them – but often they had to intercept or pursue their quarry. Poor visibility (night, fog, rain) was preferred, but conditions could not be waited upon. Smoke grenades might be used to blind the crew and/or screen the attack element's approach. The covering element might deliver the smoke, distract the tank with small arms fire, and engage enemy infantry, as would the machine gun crew. If using a stand-off weapon the attack element would move in as close as practical, to 100 yards or less; if using close-attack weapons they would have to attack the tank directly, at zero range.

Tanks were attacked from the rear quadrant if possible. Even with the more powerful portable AT weapons flank and rear shots were usually necessary to kill a tank. The use of hunter teams was hampered by normal tank tactics of seldom operating alone or without infantry support. Such an ambush was often an immediate action without specific organization or planning; small groups of infantry simply attacked tanks with whatever was available when the opportunity presented itself. This was particularly true of Japanese and Soviet troops, who might 'swarm' tanks, accepting heavy losses in the hope of destroying this high value target.

SPECIFIC WEAPONS & TACTICS

Where AT guns are discussed under the national sections below, their theoretical maximum range is omitted. Under combat conditions the greatest effective range, regardless of calibre, was seldom beyond 1,000 to 1,400 yards, and often much less.

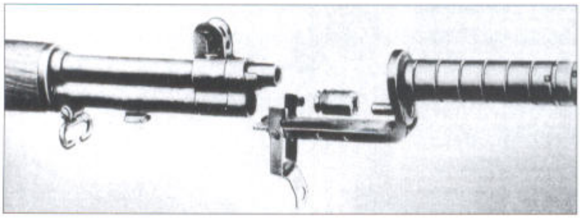
The US 37mm M3A1 gun was the mainstay of American AT defence until 1943, when it began to be replaced by the 57mm M1. The 37mm often remained in use in infantry battalion AT platoons, especially in the Pacific; it was easily manhandled over rough terrain into positions allowing it to engage pillboxes and caves. This gun in Tunisia is protected by a rock *sangar*.

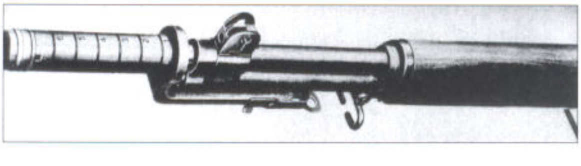
United States

Before the war America was lean on infantry AT weapons, though its doctrine was basically sound. Besides infantry AT elements, the Field Artillery was responsible for anti-tank defence; they put little effort into it, however, taking the view that their few AT guns were to protect the artillery and not the division as a whole. After testing in pre-war manoeuvres the Tank Destroyer Force was established in November 1941, and all existing divisional AT battalions were re-designated TD battalions. In a period of exaggerated fear of German armour, 220 battalions were ordered to be established. A more realistic judgement of the actual threat, and Germany's forced shift to a defensive posture, saw only 106 battalions organized, and 35 of these were never deployed overseas; some were converted into other types of unit. About half of the battalions used halftrack-mounted (later fully tracked) guns, and the others halftrack-towed guns.

The basic infantry AT weapon was the 37mm M3A1 **AT gun** first fielded in 1940; this was a copy of the German 3.7cm PaK 35/36. A good weapon when adopted, by 1941 it was outdated; production ceased in mid-1943 when the 57mm was adopted, though the 37mm often remained in use by battalion AT platoons, especially in the Pacific. It was provided with AP, APC, HE, and canister ammunition, and fired 15 to 20 rounds per minute; AP shot could penetrate only 36mm at 500 yards with a right-angled impact, though APC achieved 61mm under the same conditions. It required a crew of six, and was towed by a ½-ton or 1-ton truck.

The 57mm M1 was a copy of the British 6-pdr Mk II modified for American production; the later M1A1 and M1A2 had improved traverse gear. It could fire AP and APC rounds at 12 to 15rpm, had a ten-man crew, and was towed by a 1-ton or 1½-ton truck. Even with AP penetration of 73mm at 1,000 yards and 20°, it too was soon inadequate for European service; a replacement





Spigot-type grenade launchers, over which the hollow shaft of a grenade fitted, were adopted by the US, Germany and Japan; this is the US M7 for use on a Garand M1 rifle. It required the standard gas valve screw plug to be replaced, and was secured to the bayonet lug (like many other launchers). The further down the launcher the grenade's finned, tube-like tail boom was pushed, the greater the range. An oddity of the M7 launcher was that the rifle could not be fired semi-automatic while it was attached; at the end of the war this drawback was eliminated by the issue of the M7A1.

was sought, but none was fielded because of the abundance of tanks and tank destroyers. The 3in M5 AT gun, issued to some towed TD battalions, was a modified AA gun on a 105mm howitzer carriage.

In the Army an AT platoon with three 37mm or 57mm guns was organic to the infantry battalion's HQ company. The regimental AT company had three three-gun platoons, usually 57mm. Unlike those of most contemporary armies, the US division did not possess an organic AT unit; but a tank destroyer battalion was habitually attached at this level (except in the Pacific), with 36 x 3in or 76mm gun self-propelled tank destroyers, organized in three companies each with three four-gun platoons.

The M9A1, and other rifle-launched AT grenades, could be launched from the M1 rifle with an M7 launcher, the M1903 rifle with an M1 launcher, the M1917 rifle with an M2 launcher, and from an M1 carbine with an M8 launcher. More often than not this HEAT grenade was used against field fortifications, buildings or even personnel.

The only other AT weapon in use was the M9A1 **rifle grenade**, a spigot type. The 1941 M9 had been copied from the German GG/P40 and lacked a nose cone providing stand-off detonation; to make matters worse, the fuse was fitted to the nose rather than the base, further hampering the shaped-charge effect. It was withdrawn in favour of the 1942 M9A1 with a nose cone and base-detonating fuse, which penetrated 3 to 4in (75–100mm) of armour. Fired from the M1 rifle it had a range of about 285 yards, and from the M1 carbine, 185 yards. Range could be increased by 30–50 per cent by the use of a booster cartridge ('vitamin pill') inserted in the muzzle of the launcher tube; this was not used with the carbine, to avoid damage from the greater concussion. Until a grenade launcher became available for the semi-automatic M1 rifle in late 1943 squads used a bolt-action Springfield M1903 rifle for grenade launching. Initially there was one launcher per squad, but by 1944 the Army was issuing two or three, and the Marines one to every rifleman.

The mainstay infantry AT weapon was the 2.36in **rocket launcher** or 'bazooka'. The bazooka was light, simple to operate, and quick and inexpensive to produce. Most importantly, it was effective; and just as significant as its main role was its ability to knock out pillboxes.

The Army allotted 112 bazookas to an infantry regiment, 558 to a division; infantry battalions were issued 29, but only five to each of their three rifle companies. The remainder were assigned to headquarters, artillery, and support units throughout the division, to provide AT defence. Additional bazookas could be borrowed from the battalion HQ and heavy weapons companies.

The US Marines added 132 bazookas to their divisional establishment in July 1942, with 44 per regiment. In April 1943 the numbers were increased to 243 in a division and 53 per regiment. Like the Army, the Marines at first provided bazookas to service units; however, in May 1944 this policy was reversed and bazookas were reduced to 172 per division, with 43 per regiment, owing to the limited Japanese armour threat.

The 2.36in M1A1 bazooka and earlier M1 (note the characteristic wooden shoulder stock) required the gunner to wear face and hand protection to prevent injury from the unconsumed propellant as the rocket left the muzzle. Rather than a gas mask, as here, gunners normally wore a pair of goggles with a small facemask, though protection was often dispensed with in combat. The later M9 bazooka did not require such protection because of its longer tube and improved propellant.

The first bazookas were shipped to the British in North Africa, and to the Soviet Union. The 600 delivered to the British in September 1942 were tested and deemed unsuited for desert warfare; it was reasoned that attacking infantrymen could not approach German armour due to the lack of concealment in the desert. The bazooka's value as a defensive weapon was apparently ignored, and the British placed them in storage. By contrast, the Red Army saw their value immediately, and the first of theirs to be lost in combat provided the model for the German 8.8cm Raketenpanzerbüchse or 'Panzerschreck' ('armour terror').

The M1 bazooka saw its first American use in November 1942 in North Africa and on Tarawa; weighing 13.1lb, it is recognizable by its wooden shoulder stock and two pistol grips. The M1A1 was standardized in July 1943, though it was not fielded for some months; it eliminated the forward handgrip and had an improved electrical ignition system. Both models had a 250-yard maximum range, rate of fire of 4 to 5rpm, and were 54.5in (1.35m) long. The M9 was standardized in September 1943 at the request of the Airborne Command, and began to be fielded in mid-1944. This had a longer 61in (1.55m) tube, increasing its accuracy and range to 300 yards, and more reliable rockets. The tube could be broken down into two sections for ease of transport. The M9A1 differed only in an improved barrel-coupling latch; both models weighed 15.87lb (7.19 kilogrammes). Total production was 476,628, of which 277,819 were the M9A1 model.

The M6 HEAT rocket had a pointed nose, six long blade-like tailfins, and could penetrate 3in (76mm) of armour at 30° impact angle and 4.7in (110mm) at 90°. However, malfunctions were so frequent that its use was suspended in May 1943. The improved M6A1/A2 quickly arrived, and the M1A1 and M9 launchers could not fire M6 rockets. In August 1943 the M6A3

The 2.36in M9 and M9A1 bazookas, introduced in late 1943, could be broken down into two sections for transport, or stowed in a canvas bag for parachute jumping. The fact that it could be disassembled allowed it a longer tube to increase its range over the M1A1. The M18 was identical, but had an aluminium rather than a steel tube, to reduce weight and prevent rust; few saw service in World War II.

How the bazooka got its name

The 2.36in AT rocket launcher is universally known as the 'bazooka', a nickname which has become generic. In 1941 the US Army developed a large shaped charge AT rifle grenade, the M10; unfortunately, it was too heavy to fire from a rifle without damage, or even from a launcher on a .50cal machine gun. That same year the Army purchased a number of British 2in AA rockets for testing. In 1942, 2nd Lt Edward G.Uhl fitted M10 warheads to modified copies of the rocket motors. A 60mm steel tube was fitted with two handgrips, a shoulder stock, rudimentary sights, and a simple electrical firing system. The result was the 2.36in T1 AT rocket launcher. Major Zeb Hastings noted the weapon's similarity to an amusing musical instrument called the 'bazooka' used in his act by radio comedian and musician Bob Burns, the 'Arkansas Traveler', and the nickname stuck. While under development the bazooka was code-named 'the Whip'; it was also called the 'stovepipe', for obvious reasons.

rocket was adopted; this had a round nose to lower the angle of effective impact, a short cylindrical fin assembly with four vanes for improved stability, and an improved cone-liner in the shaped charge warhead, which increased penetration by 30 per cent. In 1944 the M10 WP rocket was approved.

* * *

US anti-tank doctrine emphasized combat outposts with some battalion AT guns temporally attached. Most battalion guns were placed near the main line of resistance with few if any provided to the reserve, and thus there was little depth of defence. Regimental AT guns were positioned to the rear of the forward battalions, or held in readiness to occupy alternate positions covering the main line or to support counter-attacks. If non-regimental AT guns were attached, usually in the form of tank destroyer companies, they could be positioned to the rear to provide more depth, as well as being attached to the screening force.

The main tasks of an AT defence were the organization of the defence of the main line of resistance and the formation of counter-attack units held in reserve. The latter was the primary function of tank destroyer units. Anti-tank weapons were not equally distributed across the front; reconnaissance was conducted to determine their deployment based on the following criteria of rising priority: (1) routes of advance that man-made and natural obstacles made impractical for tanks; (2) areas that could be interdicted by passive AT defence; and (3) zones that had to be covered by AT weapons and mines to block armour. Efforts were made to channel tanks into the third zone in order to engage them.

The major flaw in the employment of tank

The halftrack-mounted 75mm Gun Motor Carriage M3, as used by the early US Tank Destroyer Force battalions. This example is in British service in Italy, firing in a supplementary field artillery role – it proved only marginally effective for its intended mission.

US 57mm M1 AT gun partly protected by a building corner – a common means of hastily positioning a gun in a built-up area. Often rubble and debris would be piled around the exposed parts of the gun, more for concealment than cover.

destroyer units was that more often than not no German tank threat was immediately present. To employ tank destroyers gainfully they were therefore allotted to support infantry units as assault guns, often with a company to each regiment, a platoon to each battalion, and a two-gun section to each rifle company. If a major German tank attack did develop, the division's attached TD battalion was thus too widely dispersed to concentrate and conduct a counter-attack. Lack of time, and often inadequate roads usually choked with support vehicle columns, prevented the unit from concentrating rapidly in the necessary area. Tanks were found to be more effective tank-killers; and the last tank destroyer unit was inactivated in November 1946.

In the Pacific the Japanese tank threat was minimal, and relatively light AT guns were adequate for dealing with the small number encountered. The Japanese frequently employed dug-in tanks as static pillboxes, or committed them piecemeal in small numbers. When large numbers were employed in counter-attacks they were often accompanied by inadequate numbers of infantry, and were frequently committed to counter-attack a landing force too late, by which time AT guns, halftrack-mounted guns and tanks were already ashore. The US units usually made short work of the obsolescent Japanese tanks with barrages from bazookas, AT guns and artillery; often few US tanks were even present on these occasions. The first Japanese tank attack on Guadalcanal was defeated by a few 37mm AT guns (eight tanks knocked out), a 75mm halftrack-mounted gun (one tank), and 75mm howitzers (three tanks); Marine light tanks only showed up in time to mop up the enemy infantry. The largest tank battle in the Pacific saw a few Marine tanks, AT guns, bazookas and artillery destroy 24 of 37 attacking Japanese tanks on Saipan.

There were instances when US troops were overrun by German tanks, in Tunisia in winter 1942/43 and early in the Battle of the Bulge in December 1944; but for the most part US forces possessed overwhelming numbers of bazookas, AT guns, tanks, tank destroyers, artillery, and air support, defeating most armour assaults easily.

British Commonwealth

Britain entered the war with the 2-pdr (40mm) Mk I **quick-firing gun** adopted in 1938. Its design was unusual in that when it went into action its wheels were removed and three legs spread to provide a stable mount with a 360° traverse. It weighed twice as much as its German 37mm

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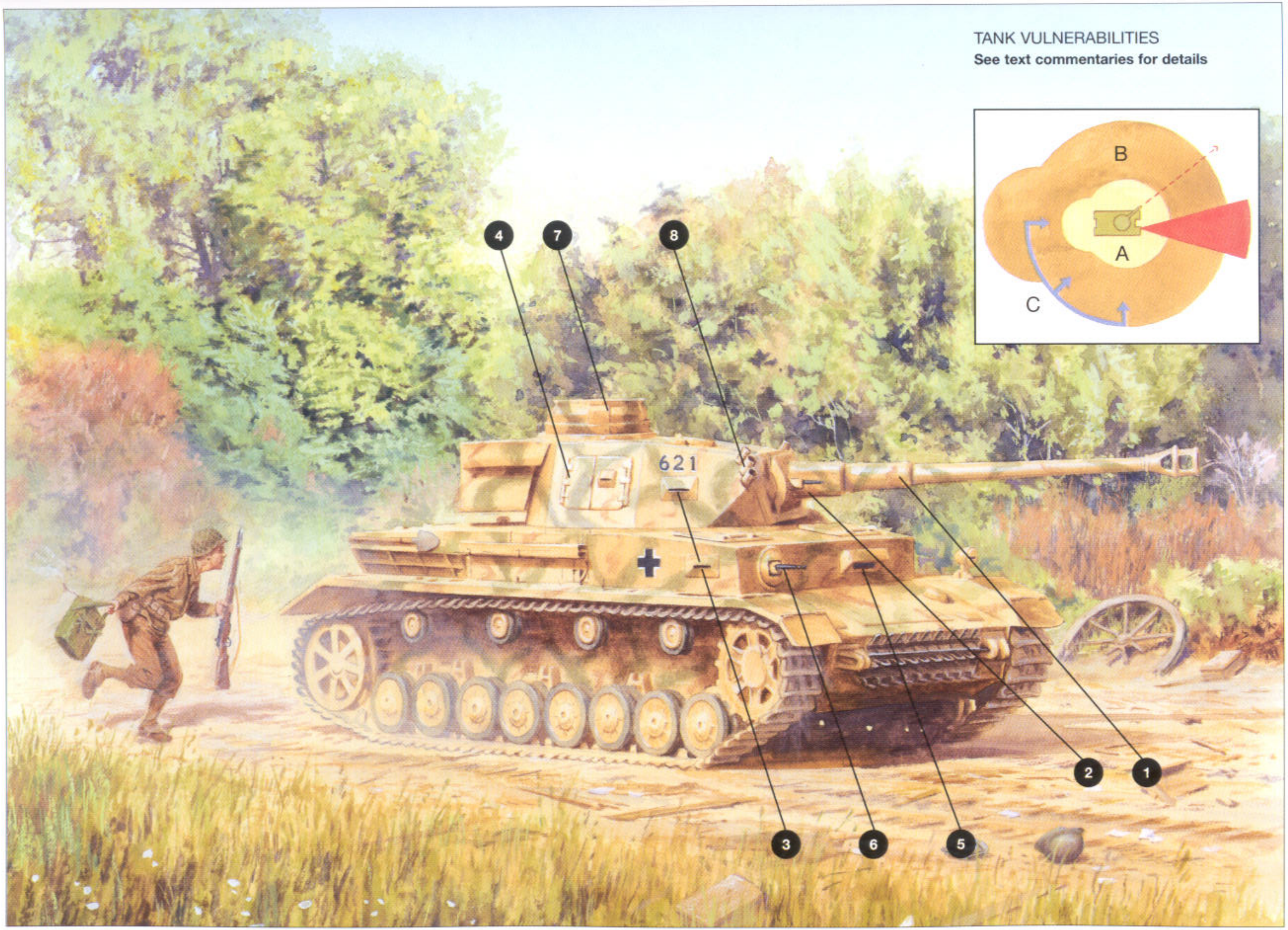
TANK VULNERABILITIES
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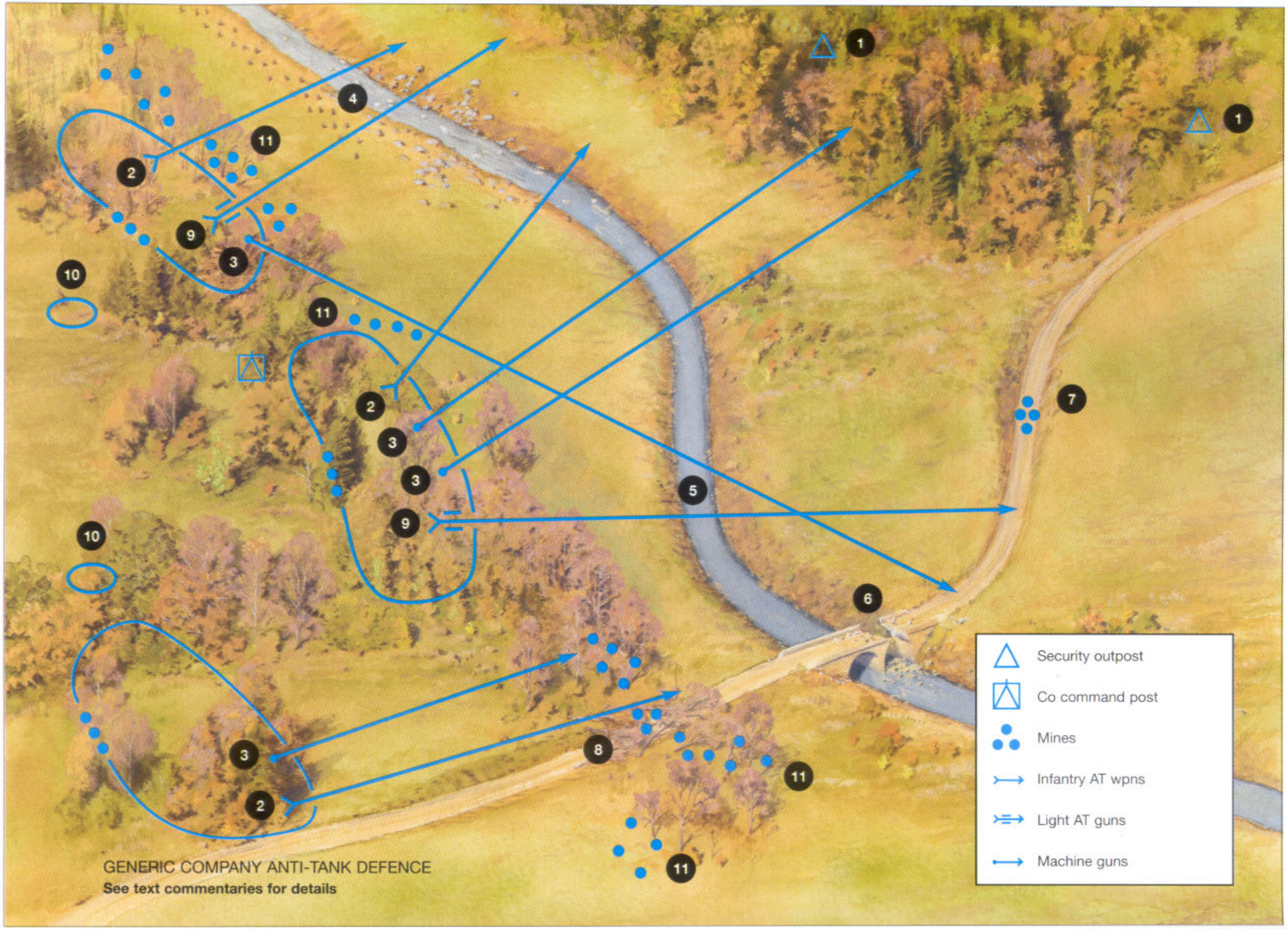

GENERIC COMPANY ANTI-TANK DEFENCE
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INFANTRY ANTI-TANK WEAPONS, 1939–40

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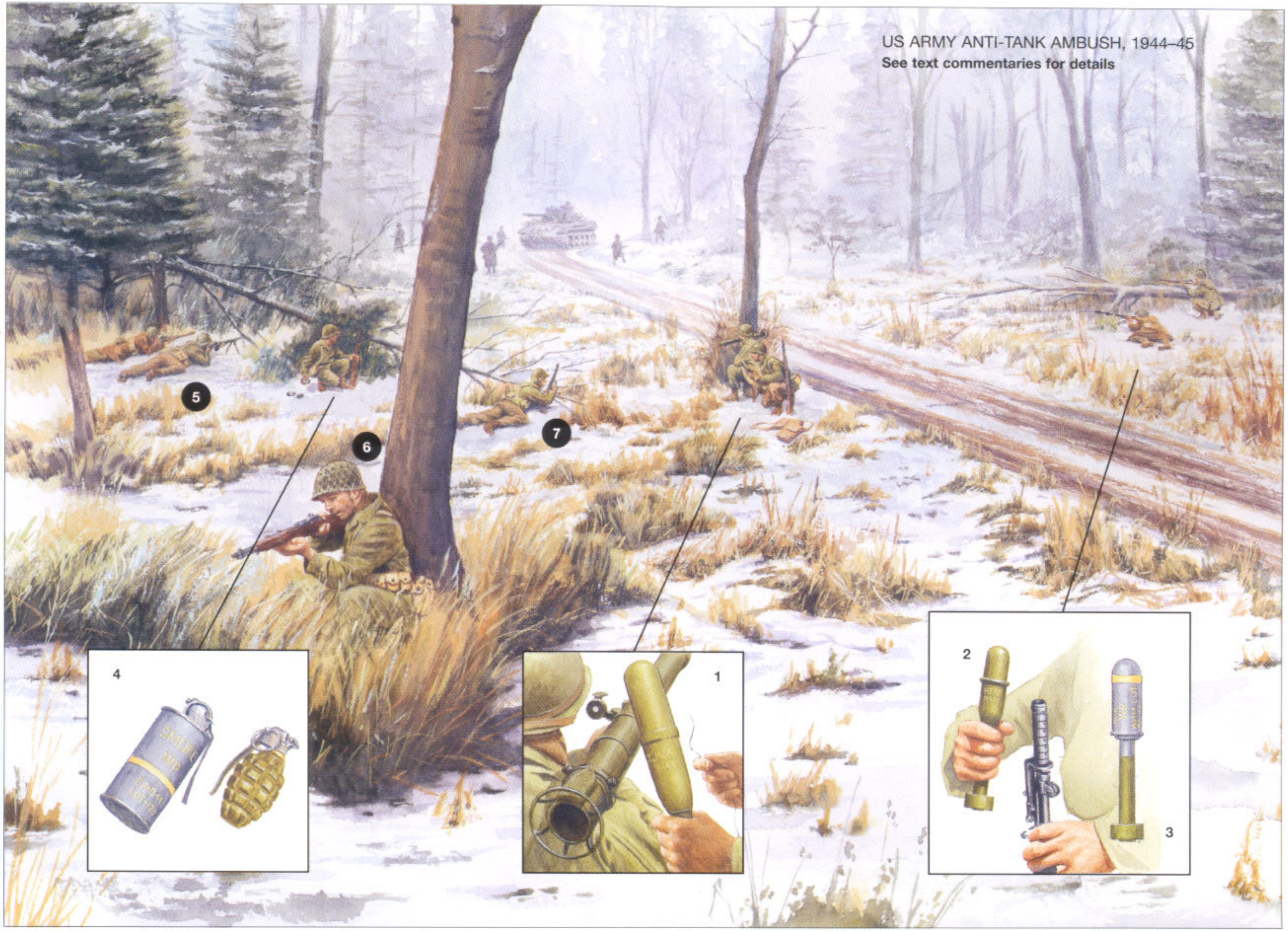
US ARMY ANTI-TANK AMBUSH, 1944–45
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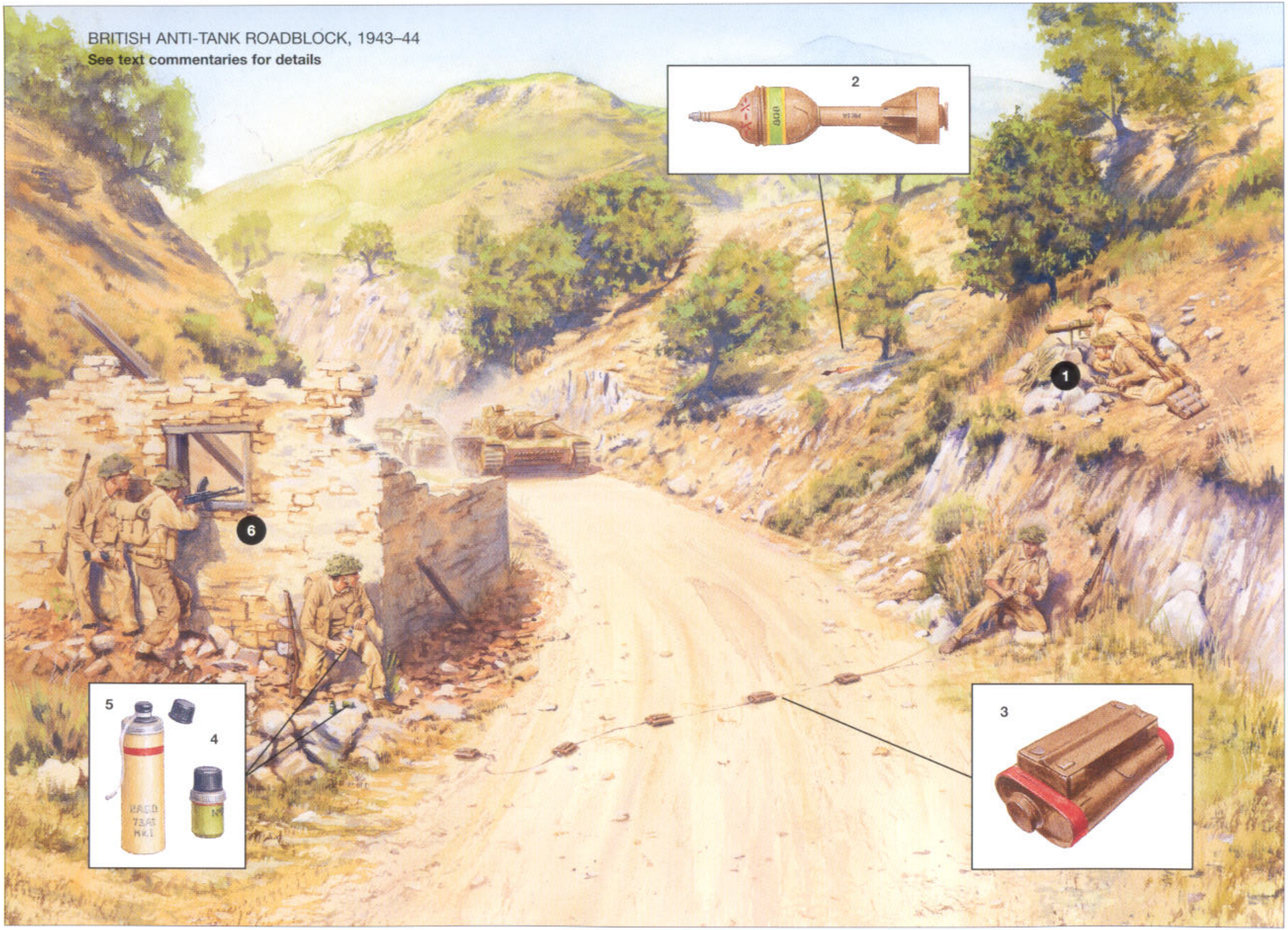
BRITISH ANTI-TANK ROADBLOCK, 1943–44
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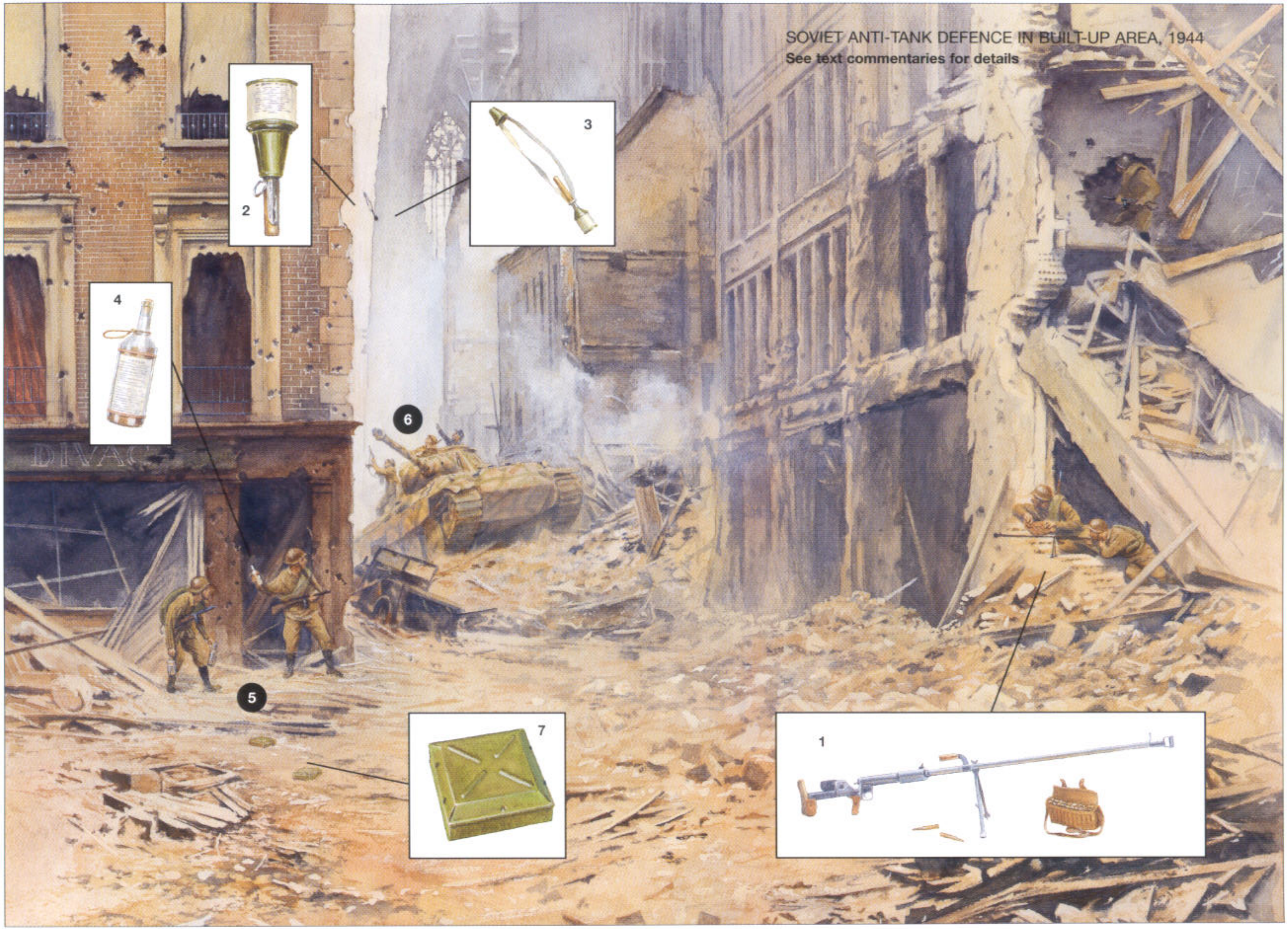
SOVIET ANTI-TANK DEFENCE IN BUILT-UP AREA, 1944
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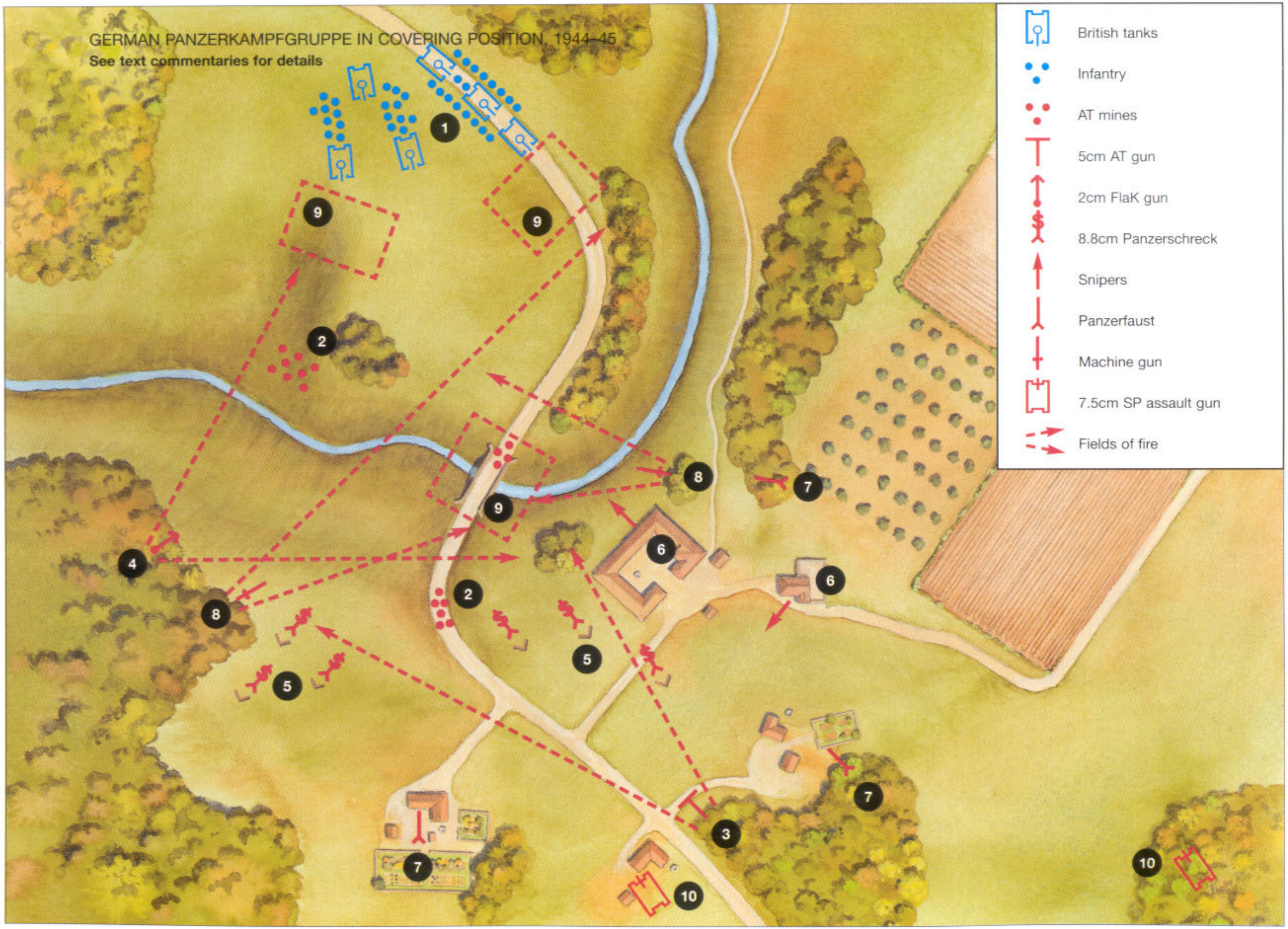
GERMAN PANZERKAMPFGRUPPE IN COVERING POSITION, 1944–45
See text commentaries for details
British tanks
Infantry
AT mines
5cm AT gun
2cm FlaK gun
8.8cm Panzerschreck
Snipers
Panzerfaust
Machine gun
7.5cm SP assault gun
Fields of fire
1
2
3
4
5
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10

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JAPANESE SELF-SACRIFICE, 1945: 'TEN MEN FOR ONE TANK'
See text commentaries for details
1
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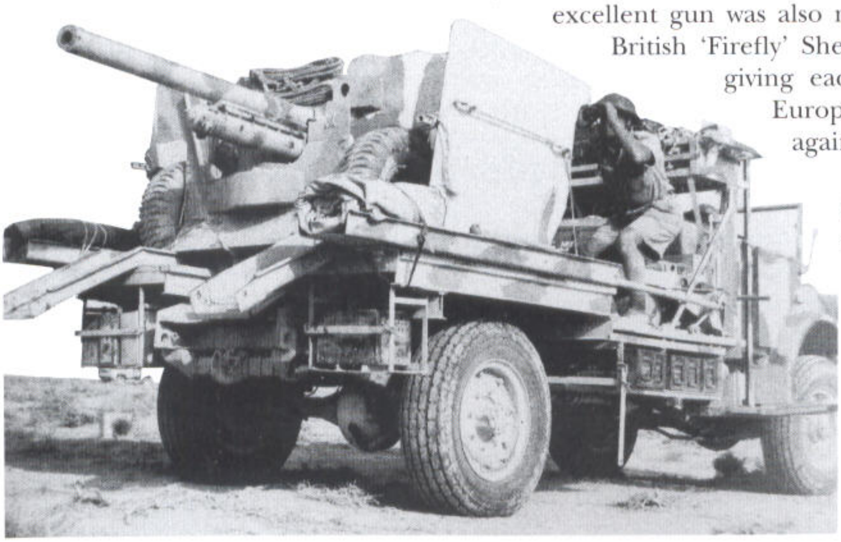
counterpart. The British envisioned it engaging tanks from well-concealed prepared positions, and mobility was not an issue. This soon proved an error; speed of emplacement and displacement was essential, and its high profile was difficult to conceal, especially in the North African desert. Its maximum effective range was 600 yards and it could penetrate 50mm of armour, which soon proved inadequate; its five-man crew could crack off 20 to 22rpm, but it was provided only with AP-tracer ammunition, thus limiting its role. It was normally transported on the back of a 1½-ton Morris truck or 'portee'. Ramps allowed it to be off-loaded for ground firing, the preferred method, but it could be fired from the truck bed. It could also be towed by a ½-ton truck or full-tracked Universal Carrier.

Large numbers of 2-pdrs were lost in France in 1940; and while the 6-pdr (57mm) gun existed in prototype, production of the 2-pdr had to continue as a stopgap in view of the desperate need for AT weapons. A number of Swedish-made 37mm m/34 Bofors guns were intercepted en route to Sudan in 1940 and impressed into service in Africa as the Mk I. Provided with AP-tracer and HE ammunition, they were only effective up to 400 yards, but weighed less than half as much as the 2-pounder. German mountain units, Poland, Denmark and Finland also used the same gun.

The 6-pdr Mk I was delivered in late 1941, to be quickly followed by the shorter barrelled Mk II, and by the Mk IV with a 16in-longer barrel. They could be porteed on a 1½-ton lorry or, more commonly, towed by a tracked carrier. The 6-pdr (see above under the basically identical US 57mm) was a well-designed, low profile weapon.

In May 1942 a much larger 17-pdr (3in) AT gun was approved for service, the first reaching the Tunisian front ('jury rigged' on 25-pdr gun-howitzer carriages) late in 1942, just in time to greet the first PzKw VI Tiger tanks deployed there. Weighing 1,822lb and with a 165.45in barrel, it fired an APC round which could penetrate 109mm (4.36in) of armour at 1,000 yards at 30°, and an HE round with a range of 10,000 yards. An APDS ('disposable sabot') round with a tungsten carbide penetrator, which could pierce 231mm (9.24in) of armour at 1,000 yards and 30°, reached the front in August 1944. (This excellent gun was also modified for mounting in the British 'Firefly' Sherman tank variant, eventually giving each tank troop in North-West Europe one tank that had a chance against the Panther and Tiger.)

The Boys 0.55in Mk I bolt action **AT rifle** was fed by a five-round magazine; it weighed 36lb and was 64in long. Adopted in 1936, by 1940 it was obsolete, being able to penetrate only 20mm of armour at 300 yards. Unpopular for its savage recoil, weight and awkwardness, it was replaced as the rifle platoon AT



Mobility was essential for AT guns. The British made wide use of the 'portee' concept, transporting 2-pdr and 6-pdr guns aboard a truck. While the gun could be fired from the truck bed, steel ramps were provided to dismount the gun for ground fire. This is a 6-pdr Mk II on a 1½-ton lorry; the side shields could also be used when in a ground position, but seldom were.

France, 1939–40: a British crew man a French 25mm Mle 1934, which the Tommies called the 'Hotchkiss'. Besides helping to meet the BEF's shortage of AT guns, this was a limited effort at weapons standardization with the French. Assigned to brigade AT companies, the 25mm was found to be a very poor weapon, only barely able to defeat the German PzKw I light tank; penetration and range were little better than those of an AT rifle, and it was too flimsy for truck towing (thus necessitating the British Army's 'portee' concept). These weapons were gratefully abandoned in France before Dunkirk.

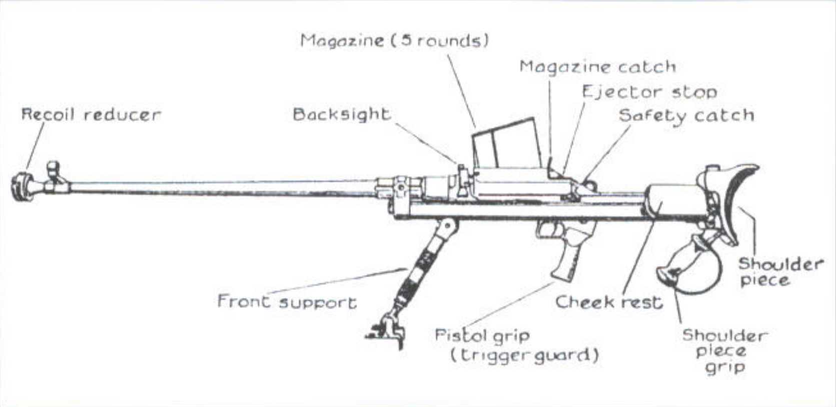
weapon in 1943 by the PIAT, but it remained in service on various light AFVs. A few hundred were employed by Finland, and they were also provided to China by the USA.

The Mk I Projector, Infantry, Anti-Tank (**PIAT** – pronounced 'pee-at') saw its first combat with Canadian troops in Sicily in July 1943. The PIAT was a spigot-type discharger; and while its round was effective, the launcher had some unique drawbacks. At 31.7lb it was heavy, but it was only 39in long. Its range against tanks was 100 yards; the 3.5in HEAT bomb could penetrate 4in (100mm) of armour, but it could hit building-size targets at 350 yards and became prized as a 'bunker-buster'. The projectile was launched by a powerful spring driving a rod into its tail and igniting a propellant cartridge. Unlike bazooka-type weapons, the PIAT itself had no back-blast; it could be fired from inside a building, and threw up no signature of smoke and dust. Mounted on a monopod, it was shoulder-fired, but there was a difficult knack to using it. Like the Boys, one PIAT was issued to each rifle platoon headquarters; some 115,000 were produced.[3]

The No.68 AT **rifle grenade** was the first British weapon to employ the shaped-charge principle. Fielded in the summer of 1940, at just under 2lb this was the heaviest rifle grenade employed in World War II. It was fired from a 2.5in cup discharger, and was fin-stabilized. The warhead had a poorly designed cavity, lacking any form of stand-off, and its flat nose degraded its accuracy. Regardless of its poor design, its ability to penetrate armour was considered remarkable in 1940. It was withdrawn from service when the PIAT was issued.

Early in the war an anti-tank school was established and operated by ex-International Brigade members with combat experience from the Spanish Civil War. A pamphlet, *Tank Hunting and Destruction*, gave advice which was relevant to a desperate last-ditch guerrilla campaign, but hardly for more conventional scenarios. In the true summer 1940 spirit of 'You can always take one with you...', it described tank-hunting as a sport akin to big game hunting, and recommended it for 'men who have bravery, resource and determination'. While a few expedient weapons were recommended, the main tank-hunting weapons prescribed were **hand grenades**, of which the British employed a wide variety. In the absence of anything like enough AT guns, they had little else with which to face the expected German invasion. All relied on blast effect, and none possessed a shaped charge; they were ineffective against all but the lightest tanks after 1940, but were retained to blow off tank tracks or for demolition and wall-breaching:

3 See Elite 122, *World War II Infantry Tactics: Company & Battalion*



The 0.55in Mk 1 Boys AT rifle saw widespread use in British Commonwealth armies; this round muzzle brake is found on British-made rifles. The Canadian-made Mk I* had a flat rectangular muzzle brake with vent holes in the edges; it also had a carrying handle, which the British model lacked. The Boys also saw limited use by US Marine Raiders and Army Rangers, as well as by the Chinese.

No.73 or 'thermos flask grenade' 3¼lb, 10–15 yards range; impact fuse armed by 'Allways' system – safety pin withdrawn in flight by unreeling of weighted tape. Used in 1940–41, withdrawn, then reissued in 1943 for demolitions.

No.74 ST or 'sticky bomb' 2¼lb, glass sphere with handle, filled with nitrogelatin (often mistakenly called nitroglycerin) and thickly covered with adhesive-soaked cloth, carried in discardable metal cover. After safety pin removed, grenade thrown or placed by hand; release of hand grip initiated 5-second time fuse. Very unpopular, but saw limited use 1940–43; after 1940 most were passed on to the French Resistance.

No.75 'Hawkins grenade/mine' 2¼lb, tin canister; initiated by various fuses, it could be used as grenade or (more commonly) landmine, as well as for wall-breaching. Reliable device, also used by US forces; in use 1942–55.

No.82 'Gammon grenade' Elasticated cloth bag in which varied amounts of plastic explosive were placed as appropriate for the target; initiated by 'Allways' fuse (see No.73 above). In use 1943–54.

To load the PIAT, the No.2 inserted the bomb into the open top of the firing tray. It needed a heavy four-finger trigger pull; there was a noticeable 'hang fire' as the massive spring driving the firing rod caused the PIAT to jerk forward, and then the propellant blast caused a recoil. This combination could loosen the firer's grip, and if he released the trigger too soon the discharge would fail to re-cock the 200lb spring. In such cases it took a man's whole body strength to twist the housing while forcing the spring back with his feet braced on the butt; trying to perform this trick in battle while staying under cover was quite challenging. (Reconstruction; photo Simon Pugh-Jones)

The No.68 rifle-launched AT grenade, and the 2.5in cup discharger fitted to the muzzle of an SMLE; the tin label reminds the firer to pull the safety pin before inserting it. The grenade's original paint finish is dark buff, with a red 'filling stripe' overlapping the threads of the screw-on cap, above green/black/green stripes identifying the filling as pentolite, the preferred shaped-charge explosive. (Photo Richard Hook)

The No.74 ST ('sticky type') AT grenade. On this example, dated December 1942, the adhesive coating has dried out to a consistency like dark brown wood; the handgrip and safety release are of black bakelite and bare metal respectively. This was one of a box full of 'sticky bombs' recovered recently in Normandy, where they were presumably buried by the *Maquis* before D-Day. (Photo Richard Hook)

The 2-pdr anti-tank gun was first assigned to the divisional AT regiment, a battalion-size Royal Artillery unit; these had four batteries of 12 guns each. A battery was attached to each divisional brigade, consisting of three four-gun troops, one attached to each infantry battalion. The 2-pdrs were replaced with 6-pdrs in 1942, and during 1944–45 batteries gradually achieved one troop with 6-pdrs and two with the much superior 17-pdr gun. The number of AT guns available to a division was inadequate, and in 1942 each infantry battalion's HQ company additionally received a platoon of six 2-pdrs, later 6-pounders.

All too often the four 2-pdrs supporting an infantry battalion were employed in a straight line across the defensive front, allowing them only frontal shots at tanks they could not defeat. This made them easier to detect – when one was spotted the others were to be found immediately to its flanks. Whether in desert or woodland, it was found that they had to be employed in staggered lines with one or more positioned to achieve side shots.

The British began the war with a doctrine specifying a continuous front line protected by an anti-tank obstacle, and the dictate 'Troops allotted to the defence of a locality must defend it to the end without a thought of withdrawal...' Positions were to be placed in depth. In North Africa this doctrine was largely replaced by a much more realistic 'box' concept of in-depth strongpoints on tank-proof terrain protected by minefields and screened by outposts and patrols.

Because of the inadequacies and insufficient number of 2-pdr guns, field artillery was heavily employed in North Africa to supplement them. The 2-pdrs were directed not to engage tanks until within 800 yards, and closer in wooded terrain. Opening fire at 600 yards was found to be too close, since tank machine guns were then within effective range. At 800 yards AT guns were as accurate as at 600, while machine guns were less accurate and unable to penetrate gun shields. The field artillery's 25-pdr gun-howitzer had the advantage of 360° traverse and a 20rpm rate of fire with AP rounds; 25-pdrs opened fire within 1,000 yards, but were marginal tank-killers except at short range.

The 2-pdr guns were also positioned behind the front line to protect artillery regiments, and their AT fires were integrated. The 2-pdrs might be positioned 100 to 300 yards to the flank of the artillery, or if all-round protection was necessary, as much as 500 to 1,000 yards to the front and flanks. The use of 25-pdrs as AT guns also provided depth to the anti-tank defence. As more 6-pdr and heavier guns became available, along with self-propelled AT guns, the reliance on artillery faded. Guns were positioned to concentrate fires, as German tanks usually attacked in a mass which could not be engaged effectively by single guns.

In Burma and other jungle areas Japanese tanks were largely restricted to roads and Commonwealth forces concentrated AT guns along the roads in great depth. A definite forward line of the AT defence was specified, as was a rear line beyond which tanks were not allowed to pass.

Rifle platoons relied on their single Boys AT rifle or PIAT and various AT hand grenades. Expedient means of attacking tanks were widely encouraged early in the war, but these proved to be only marginally effective. Camouflage and dispersed deployment were considered a key factor in AT defence.

The British 2-pdr Mk I AT gun weighed 1,858lb, about twice as much as its US and German 37mm counterparts. It could be fired from its wheels, but they were normally removed for action and the gun set up on its integral three-legged mounting. Side shields were available, but seldom used.

Soviet Union

The USSR began the war with the 45mm M1932 and M1937 **AT guns** for *protivo-tankovaya oborona* ('anti-tank combat'). These were rebarrelled 37mm M1930 and M1932 guns, almost exact copies of the German PaK 35/36, the identifying difference being wire-spoked wheels. In 1941 the short-barrelled 37mm was also still in use, though it penetrated only 40mm of armour at 500 yards. Both calibres fired AP and HE ammunition. The 45mm M1942 was essentially an M1937 with a one-third longer barrel, increasing its velocity and thus penetration to 60mm at 500 yards; this was still inadequate, but the M1942 remained the primary battalion and regimental AT gun. A high-velocity round, based on a German design, was introduced in April 1942; this could penetrate 80mm at 500 yards. Apart from improved penetration the 45mm offered a more effective HE round than the 37mm.

Theoretically a platoon with two guns, either 37mm or 45mm, was allocated to each rifle battalion, and four or six guns to a regimental AT battery. In the event insufficient guns were available to continue equipping battalion platoons, and they were dropped between July 1941 and January 1943. The 45mm also armed divisional AT battalions, each with three four-gun batteries. The AT battalion was deleted from the divisional establishment in July 1941, but restored in January 1942. During that period the only AT guns were those assigned to regimental batteries.

The Soviet 45mm M1942 AT gun partly replaced the 45mm M1932 as well as 37mm guns. The 45mm began to be replaced by the 57mm ZiS-2 in late 1943, but earlier models remained in use. Its long barrel coupled with a new high velocity round made the 45mm a reasonably effective weapon for its calibre. The USSR was the only country to use 45mm guns.

The Soviet 14.5mm Degtyarov PTRD-41 AT rifle (see also Plate F), with a length of 6½ft, was actually reasonably light for its size at 17.44kg (38lb). The barrel could be separated from the action at the point where the assistant gunner's hand rests in this photo; on the march the No.2 carried the barrel and the No.1 the action.

Production of the 57mm ZiS-2 began in 1941, but it was halted when Soviet intelligence assessed German tank armour as thinner than had been believed. Production was resumed in June 1943, with an improved carriage. With a rate of fire of 20–25 rpm, it could penetrate 145mm at 500 yards; it fired both high velocity AP and HE rounds, and had the longest barrel of any gun in this calibre range. The 57mm was to replace the 45mm at divisional level, but often the necessary prime movers were unavailable, and divisions retained manhandled 45mm guns. From 1943 independent AT battalions and brigades were raised.

The standard divisional artillery piece was the 76.2mm F-22 of 1936 and the improved 1939 FS-22USV gun; the 76.2mm ZiS-3 was introduced in early 1942. The 76.2mm guns were long-barrelled weapons suited for AT use, and the Germans employed many captured F-22s in that role. The Soviets also adopted a massive 100mm BS-3 AT gun in 1944.

The Red Army were the war's largest users of **anti-tank rifles**, producing some 400,000. Two models were employed, both of 14.5mm calibre, bipod-mounted, long and heavy, but capable of being broken down into two sections. The Degtyarov PTRD-41 was single-shot, bolt-action, 78.74in (1966mm) long, and weighed 38lb (17.44kg). The Simonov PTRS-41 was semi-automatic with a five-round magazine; its 84.25in (2006mm) length and 46lb (21kg) weight, coupled with its complexity and cost, resulted in its seeing much less service. The 14.5mm B-32 AP-incendiary round penetrated 35mm of armour at 100 yards and 25mm at 500, while the tungsten carbide-cored BS-41 AP-I punched through 40mm at 100 yards and 35mm at 500.

Both weapons were adopted in August 1941, and a platoon of six was added to the rifle regiment establishment. They saw their first combat use only in November 1941, and the regimental scale was increased to a company of three platoons, each with three squads, each with three rifles – a total of 27 weapons. An AT rifle company was added to the rifle battalion in July 1942, with two platoons of four squads (16 rifles), as well as a four-platoon company in the divisional AT battalion (36 rifles). In January 1943 the battalion company was reduced to a nine-rifle platoon. AT rifles were also distributed to many other types of units. Although they were soon obsolete, AT rifles remained in Soviet use throughout the war. Tactics emphasized side and rear attack, as well as use against the many light AFVs encountered on the battlefield.

With the acquisition of 8,500 US 2.36in M1 bazookas through Lend-Lease in 1942, the capture of various German rocket launchers in 1943, and their own vigorous Katyusha artillery rocket programme, it is surprising that the Soviets did not develop an effective shoulder-fired AT rocket launcher to replace the obsolete, heavy, awkward and costly

AT rifles. They did make extensive use of captured Panzerfausts; and Britain provided 3,200 Boys AT rifles and 1,000 PIATs.

In 1941 the Soviets fielded an unusual weapon known as the *ampulomet* ('ampoule projector'), with six assigned to the rifle regiment's 'anti-tank mortar' platoon. This was a short 125mm tube on a four-legged mount firing a glass sphere filled with jellied petrol/gasoline to a range of 250 yards; it had a crew of three men. Inaccurate and largely ineffective against tanks, it was withdrawn in late 1942. The use of man-portable flamethrowers against tanks was common, however.

The VPGS-41 AT **rifle grenade** was a heavy, fin-stabilized rod-type grenade, requiring no separate launcher attachment for the rifle. Its poorly designed shaped charge lacked sufficient stand-off and had an almost flat nose, degrading its accuracy. It was phased out in about 1943 due to its short 50 to 75 yard range, limited armour penetration, and damaging effect on rifles.

The Soviets employed three AT stick **hand grenades**. These were heavy, about 2¼lb, limiting throwing range to about 15 or 20 yards. All were stabilized by deployable ribbon drogues. The RPG-40 *(ruchnaya protibotankovyi granata,* 'hand anti-tank grenade') was a blast grenade penetrating 20 to 25mm of steel; it was more effective against pillboxes than armour. The RPG-42 used a shaped charge to penetrate 75mm; and the RPG-6 was a much improved design introduced in 1944, with 100mm penetration. Apart from these grenades, 'Molotov cocktails' were produced in their millions, and self-igniting kits were provided to attach to bottles in the field.

* * *

Soviet AT defences emphasized depth: 2–3km in 1941 (1¼–1¾ miles), and four times that depth by the time of the battle of Kursk in mid-1943. Co-ordination between units, and a strong mobile AT reserve, were also major factors. Anti-tank units were called 'anti-tank artillery', and field artillery units were also trained to conduct direct fire on armour. Light AT guns were positioned well forward, but not beyond the infantry front line, with progressively larger calibre guns in subsequent lines. Large calibre guns could be positioned forward to cover key avenues. Anti-tank guns were covered by infantry and AT rifles, and were positioned in pairs within 50 yards of each other. Sometimes guns were positioned 100 to 150 yards apart along the front. Camouflage and alternative positions were heavily emphasized, and fire was held until tanks were within 600 yards at most to avoid revealing positions prematurely. Four guns were often positioned in a diamond pattern to provide all-round fire.

Anti-tank guns and artillery were expected to fire until overrun; the destruction of large numbers of tanks was considered a successful defence even if the guns were lost. The Soviets

A staged photo of a Red Army AT rifle crew taking on a PzKw III. Note that both men carry the haversacks containing 20 rounds of 14.5mm AP-I cartridges.

calculated that 12 x 45mm rounds were necessary to knock out a tank, whether fired from one gun or several; this allowed for misses and deflected hits. Typically, one 45mm gun was lost for every tank destroyed. The 76.2mm required half the number of rounds to destroy a tank, and typically knocked out two or three before being destroyed itself.

The 'fire sack' was a pre-planned zone into which minefields, obstacles, and fire would channel armour – a large scale ambush. Several AT units would be positioned on both sides of the kill zone, to engage the tanks from different directions and ranges. Massed artillery fires were concentrated on the zone, and mobile AT guns would attack it. An AT reserve would be held, to manoeuvre into position to block escaping tanks even if the enemy changed direction.

Divisional and higher commanders established an AT reserve *(protivotankovyy rezerv)*; at division level this was constituted from part of the AT battalion and one platoon from each regimental AT battery. Tanks and mobile obstacle detachments might be included – the latter laid hasty minefields on enemy tank routes.

The use of AT strongpoints was customary in the summer 1943 defensive battles. A typical strongpoint engaged in the battle of Kursk was built within a rifle company position; it might consist of three or four 45mm AT guns, two or three AT rifle squads, a sapper squad with demolition charges, a sub-machine gun squad, and tank-hunter teams with Molotov cocktails and other close-attack weapons. Up to 1,700 mines were laid per kilometre (⅔ mile) of frontage, along with AT ditches and other obstacles, all covered by pre-planned artillery concentrations.

At least ten AT rifles were to be committed against a tank platoon, and instructions provide an idea of their employment: 'In all cases establish secondary firing positions; fire five to ten rounds from one position, then move to another. If the enemy tank is moving in a direction unfavourable to you, quickly and inconspicuously occupy another position to fire into the side or rear from 50 to 100 yards.

'Manoeuvring on the battlefield, force the tank into the fire of another AT rifle; in those cases when you are operating with other AT rifles, and in a combat formation with our own infantry, co-ordinate your own mission with that of your neighbour. When supported by grenade and Molotov cocktail throwers, determine their positions and do not fire in their direction. If an enemy tank has halted, disable its weapons first.'

The German 3.7cm PaK 35/36 AT gun was extensively copied by other countries including the US, USSR and Italy, as well as being exported to the Netherlands and China. The shield was usually high, but the upper portion was hinged (level with the loader's helmet top in this photo) and could be dropped forward to lower its profile.

Germany

Despite all their emphasis on mobile armoured warfare, the Wehrmacht entered the war with marginal anti-tank capabilities. The army was so oriented toward aggressiveness that anything smacking of defence was viewed with disfavour. 'Armour defence' (Panzerabwehr) units were redesignated 'armour hunter' (Panzerjäger) on 1 April 1940, to play down their defensive nature. Anti-tank guns were increasingly mounted on tracked chassis to improve mobility.

The principal **AT gun** was the Rheinmetall-Borsig 3.7cm PaK 35/36 (Panzerabwehr Kanone, 'armour defence gun', model 1935/36). Nine guns were allotted to the three-platoon regimental AT company and 27 to the divisional AT battalion. Copied by many countries, the PaK 35/36 was an excellent weapon in the mid-1930s, but by 1940 it was obsolescent – as acknowledged by its army nickname of 'doorknocker' *(Türklopfer)*. Operated by a six-man crew, it originally fired an AP round that could penetrate 40mm at 400 yards; in 1940 the AP40 round was introduced, penetrating 50mm at 400 yards. In 1941 a massive muzzle-loaded shaped charge 'rod grenade' was developed to extend the gun's life; this Steilgranate 41 had a 159mm (6.36in) warhead which rested outside the muzzle, capable of penetrating 150mm of armour with an effective range of 200 yards, although much longer ranges could be achieved.

The 5cm PaK 38, a scaled-up version of the 3.7cm, was fielded in late 1940 to replace the 'doorknocker,' but supply was slow. With a good shot it could knock out a T-34 with the AP40 round, which penetrated 85mm at 500 yards, while the standard AP penetrated 60mm at that range. The Germans were so badly in need of AT guns that they employed just about all captured ordnance in this role, but numbers were still insufficient. They also built several hybrid designs mating AT guns to artillery carriages.

A further scaling up of the PaK 38 resulted in the 7.5cm PaK 40, also fielded in late 1940. This became the main divisional AT gun, but some were assigned to regimental AT companies as well. Heavy to manhandle, it nonetheless proved to be an effective weapon. It could knock out most tanks, penetrating 105mm at 500 yards with standard AP, and 115mm with AP40. Many captured Soviet 76.2mm FS-22 guns were rechambered for German 7.5cm and further modified for AT use as the 7.62cm PaK 36(r). The 3.7cm, 5cm, and 7.5cm were all provided with HE rounds.

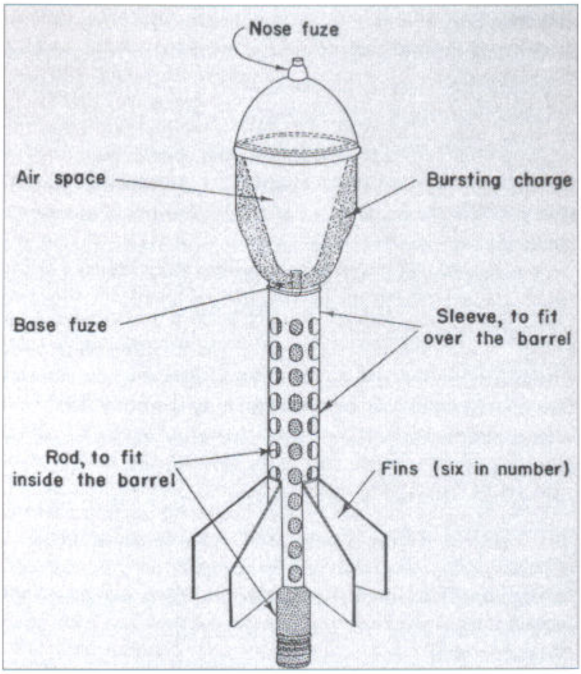
From 1941 the Germans made limited use of two Gerlich-type tapered or **'squeeze' bore guns**, the 2.8cm (tapering to 2cm) and 4.2cm (actually 4.5cm, tapering to 2.94cm). The 2.8cm sPzB 41 was a small, wheeled weapon meant to replace 7.92mm AT rifles, and the 4.2cm lePaK 41 was mounted on a 3.7cm

This 7.5cm PaK 40 is typical of World War II anti-tank guns: it has a long barrel for high velocity and range, a muzzle brake to reduce recoil (since the guns were kept as light as possible), a shield to protect the crew from tank machine gun fire and fragmentation, rubber tyres for high-speed towing when repositioning, split trails, direct fire optical sights, and a means of rapid traverse. To be successful and to have any chance of surviving, AT guns also needed camouflage and protection. This gun appears to have been well camouflaged, though most has been pulled away to allow the position to be photographed. The low-profile gun has been dug into a pit, and a slit trench dug for the gunner and loader immediately beneath the breech. This view illustrates the double, spaced shield typical of many German AT guns; it required the use of less steel and reduced weight, while equating to the protective effect of a solid shield approximately one-third thicker.

carriage. These guns used a special projectile that was 'squeezed' down to a smaller calibre when fired in order to achieve a higher velocity. Guns and ammunition were expensive to produce – the rounds required scarce tungsten carbide cores – and production ceased in 1942. Penetration was good: the 2.8cm achieved 60mm at 400 yards, and the 4.2cm, 75mm at 500 yards. Their usefulness was limited by their lack of HE rounds.

The 2cm FlaK 38 single and quad AA cannon were integrated into anti-armour defences and provided with AP and AP40 ammunition, as were the 3.7cm FlaK guns.

The Germans had small numbers of **AT rifles** in service in 1939, the Panzerbüchse (PzB) 38 and 39. Only 1,600 examples of the complex and expensive PzB 38 were produced, but 39,232 of the PzB 39. Both models were 7.92mm calibre, taking a necked-down 94mm-long World War I 13.2mm AT rifle cartridge, capable of penetrating 30mm at 100 yards. The bullet was too small to do much interior damage; a larger round would ricochet around and hit different crewmen, but the little .31cal bullet would usually stop when it hit the first man. The early rounds had a tiny tear gas pellet, but this was too small to be effective. Later ammunition had a carbide core – something learned from the Poles. Both rifles were single-shot and bipod-mounted. The PzB 38 weighed 35lb (15.99kg) and the PzB 39, 27.25lb (12.43kg). Several other 7.92mm AT rifles saw limited use, along with numerous captured weapons including Soviet types, and various Swedish-made 20mm rifles such as the Solothurn s18-1100. A rifle company had a seven-man AT section with three weapons; one might be attached to each platoon, but it was preferred to keep them grouped for concentrated fire.

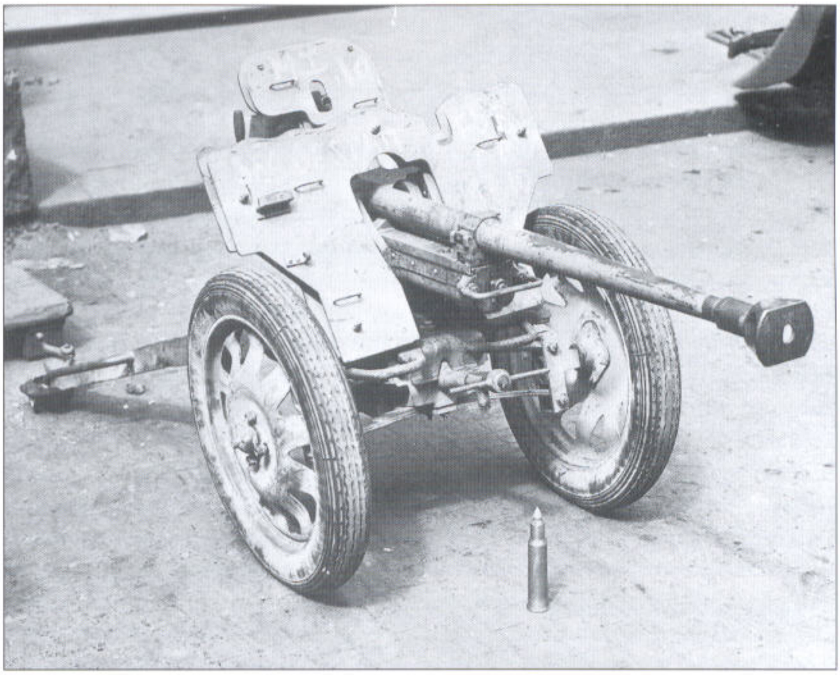


To extend the life of the 3.7cm PaK 35/36 this *Steilgranate 41* round was produced in 1941. It was essentially a rod-type 'rifle grenade' loaded in the bore of the gun, with the finned sleeve sliding down outside the barrel. It could penetrate 150mm (6in) of armour at its effective range of 200 yards at 5 degrees elevation.

Recognizing that they were outdated, in 1943 the Germans modified the PzB 39 into the Granatbüchse (GrB) 39 **AT grenade rifle**, shortening the barrel by 2ft and attaching a grenade discharger cup. Capable of firing any German AT grenade, it was still heavy at 23.15lb (10.5kg), and its range of 150 yards was not much further than the same grenades could be fired from a standard rifle.

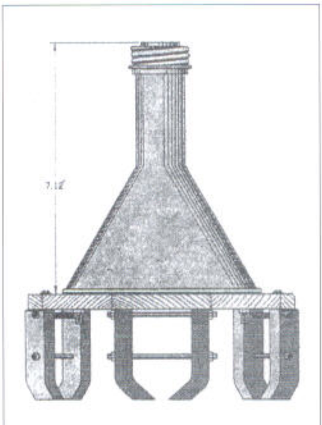
The '**rifle grenade** for anti-armour combat model 1940' (Gewehrgranate zur Panzerbekämpfung 40 – GG/P40) used a spigot-type launcher. The grenade, copied by the US, was ineffective even though the Germans used a base-detonating fuse; it lacked stand-off. It was withdrawn in 1942 and replaced by a 30mm cup discharger system. The first 'rifle armour grenade' (Gewehr Panzergranate) was a 30mm shaped charge with 20 to 30mm of penetration and an effective range of 50 to 100 yards. By 1942 a 40mm over-calibre grenade was introduced, capable of penetrating 50mm at up to 150 yards. Almost 24 million 30mm and 40mm grenades were produced. The 46mm and 61mm versions were introduced in late 1942 and late 1943 respectively, with an effective range of 80 to 100 yards. The 46mm penetrated 70 to 90mm, and the 61mm pierced 100 to 120mm.

The 2.8cm *schwere Panzerbüchse 41* (sPzB 41) employed the Gerlich tapered bore principle, 'squeezing' the projectile to 2cm. Intended to replace 7.92mm AT rifles in infantry companies, it saw only limited issue because of high production costs and the scarcity of the tungsten necessary for its AP rounds. There was no traversing or elevating mechanism; it was freely traversed and elevated using handgrips near the breech.



While a few AT **hand grenades** saw limited use, the principal German hand anti-tank weapon was the magnetic hollow charge 3kg Haft-Hohlladungen (Haft-Hl 3). This 'armour-cracker' (Panzerknacker) was adopted in November 1942. It was of truncated cone shape, with a handle holding the fuse, and three pairs of magnets around the base which allowed it to be attached to a tank, fortress gun cupola, and pillbox doors or shutters. Early models had a friction-ignited 4.5 second delay fuse, which sometimes did not allow time for the attacker to seek cover; a 7.5 second fuse was introduced in May 1943. The charge could penetrate up to 140mm of armour or 20 inches of concrete. Some 553,900 'armour crackers' were made in 1942–44; the Haft-Hohlladung was declared obsolete in May 1944, to be replaced by the Panzerfaust, although existing stocks remained in use.

The 3kg *Haft-Hohlladungen* was a hollow charge fitted with three pairs of magnets (*Haften* means 'to cling'). This hand-placed 'armour-cracker' actually weighed 3.6kg, being filled with 3kg (6.6lb) of pentolite. The magnets were termed 'Alnico', which is often assumed to be a maker or designer name, but is actually a contraction: 'AlNiCo' for aluminium-nickel-cobalt, an alloy used for making magnets.



The 'anti-armour thrown mine type 1' (Panzerwurfmine 1) was a 3lb (1.35kg) hand-thrown hollow charge mine issued in 1944. It consisted of a hemispherical-nosed warhead with a long tailboom and four folding cloth vanes. When it was thrown the igniter was armed and vanes opened like an umbrella to stabilize the mine. Its range was 20 or 30 yards and it was considered to be quite effective – penetrating 80 to 100mm – but somewhat unsafe to handle.

The 8.8cm Racketenwerfer 43 ('**rocket launcher** model 1943') or *Püppchen* ('Dolly') looked like a small artillery piece, a breech-loading tube on two wheels. Its HEAT rocket was effective to 230 yards against moving targets and up to 500 for stationary targets, to penetrate 160 millimetres. The weapon was not recoilless and there was no back-blast. It was expensive to make, and insufficiently portable for infantrymen, its 325lb (149kg) weight being broken down into seven sections for man-packing.

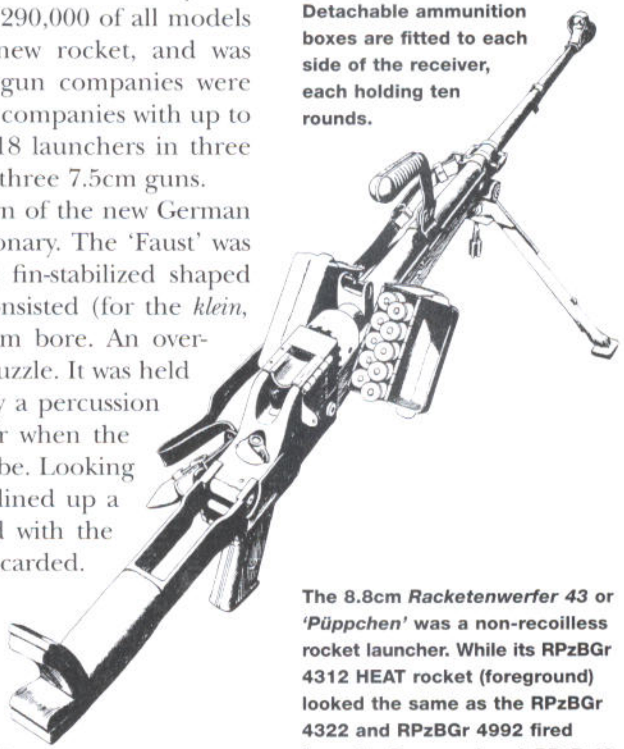
Captured American 2.36in M1 bazookas led to a new design, the 8.8cm Raketenpanzerbüchse (RPzB) 43, also known as the *Panzerschreck*

('armour terror') or *Ofenrohr* ('stovepipe'). This electrically fired shoulder weapon was 65in (1638mm) long and weighed 209lb (9.5kg); it used the same 8.8cm warhead as the Püppchen, but with a redesigned motor, and had a range of 150 yards. The Panzerschreck was highly portable, low cost, and could be produced rapidly in large numbers. The almost identical RPzB 54 was produced in 1944; this weighed 24.2lb (11kg) because an added shield protected the gunner from muzzle blow-back. Only a small number were produced before the RPzB 54/1 appeared, with a shorter 52.5in (1333mm) tube and its weight reduced to the former 9.5kg; this could fire an improved rocket to 180 yards. This was the most common model of the almost 290,000 of all models produced. (The RPzB 43 could not fire the new rocket, and was reissued to second line units.) Regimental AT gun companies were replaced by 'armour destroyer' (Panzerzerstörer) companies with up to 54 Panzerschrecks in three platoons, each with 18 launchers in three squads. Some companies retained a platoon with three 7.5cm guns.

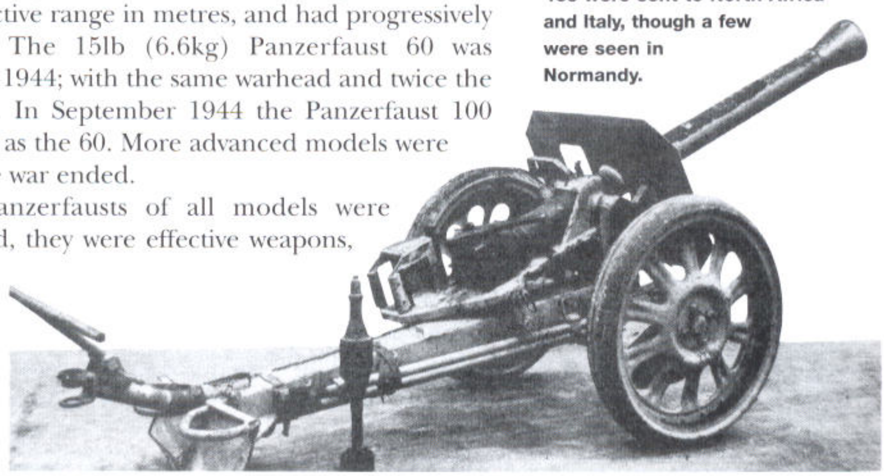
The *Panzerfaust* ('armour fist') is the best known of the new German anti-armour weapons, and was genuinely revolutionary. The 'Faust' was actually a single-shot recoilless gun launching a fin-stabilized shaped charge warhead with a propellant cartridge. It consisted (for the *klein*, 'small' model) of a 35in-long steel tube of 44mm bore. An over-calibre shaped charge warhead was fitted to the muzzle. It was held under the arm or over the shoulder, and fired by a percussion igniter, which was exposed to the rocking trigger when the gunner flipped up a folding sight on top of the tube. Looking through one of three apertures in the latter, he lined up a barleycorn sight on the top edge of the warhead with the target. Once fired, the non-reloadable tube was discarded.

The first Panzerfaust *klein* model, issued in July 1943 (aka Panzerfaust 1, or *Gretchen* – 'Peggy'), had a 100mm diameter warhead, weighed 3.3lb (1.5kg), and penetrated 140mm of armour at 30 yards. The Panzerfaust 30 (aka Panzerfaust 2 or *gross*, 'large') followed immediately; it had the same range, but it and subsequent models employed a 6.6lb (3kg) 150mm warhead capable of penetrating 200mm at an impact angle of 30 degrees. The *gross* weighed 11.5lb (5.22kg) in total. This and subsequent models were designated by their effective range in metres, and had progressively larger propellant charges. The 15lb (6.6kg) Panzerfaust 60 was introduced in the summer of 1944; with the same warhead and twice the range, it saw the widest use. In September 1944 the Panzerfaust 100 appeared, weighing the same as the 60. More advanced models were under development when the war ended.

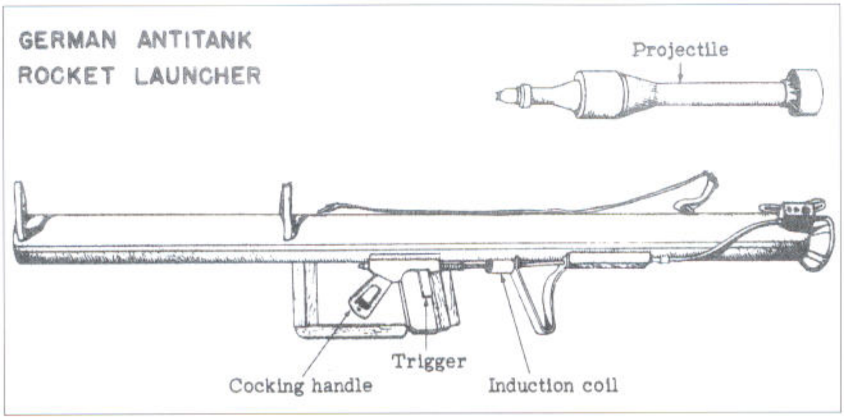
More than 8 million Panzerfausts of all models were produced. While short-ranged, they were effective weapons, mainly because of the sheer numbers available. They had no specialist crews, but were issued to individuals just like grenades; indeed, in the closing months of the war German propaganda made



One of several AT rifles used by the Germans, the 7.92mm PzB 39 was single shot with semi-automatic ejection. To load, the pistol grip is pulled forward and downward and the breechblock opens. After firing this action is repeated, and the opening breechblock ejects the spent cartridge. The PzB 39 has a folding buttstock and the bipod is adjustable for height. Detachable ammunition boxes are fitted to each side of the receiver, each holding ten rounds.



The 8.8cm *Racketenwerfer 43* or *'Püppchen'* was a non-recoilless rocket launcher. While its RPzBGr 4312 HEAT rocket (foreground) looked the same as the RPzBGr 4322 and RPzBGr 4992 fired from the *Panzerschreck* RPzB 43 & RPzB 54, and RPzB 54/1 respectively, they were not interchangeable. Most R-Werfer 43s were sent to North Africa and Italy, though a few were seen in Normandy.



Copied from US bazookas captured in Russia, the much larger 8.8cm RPzB 43 *Panzerschreck* was quickly adopted by the Wehrmacht. It was soon replaced by the RPzB 54, which appeared almost identical apart from an added face shield (sometimes removed in combat). Both fired the RPzBGr 4322 rocket. The shorter RPzGr 54/1 model fired the improved RPzBGr 4992 rocket as well as the 4322, but the 43 and 54 could not fire the new 4992.

much of the fact that Hitler Youth teenagers, old Volksturm home guardsmen, and even housewives could be trained to use them. Allocation to infantry divisions was 36 per rifle and pioneer company, 18 per AT company and other company-size units, and 12 per artillery battery.

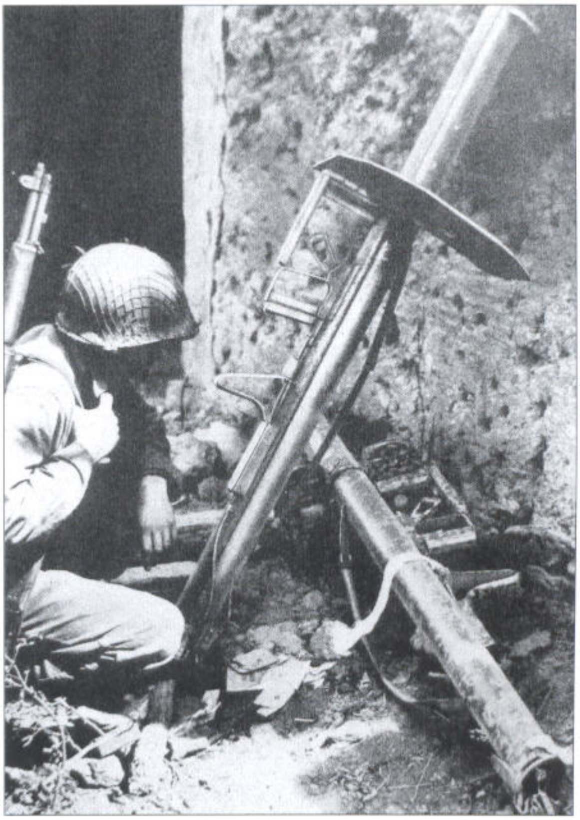
* * *

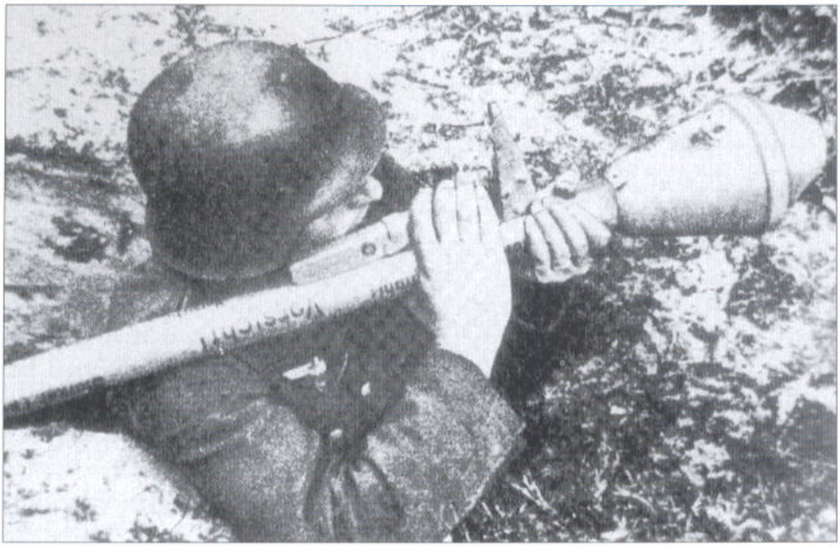
German anti-armour doctrine called for all units including rear services to prepare for tank defence by emplacing AT weapons to cover likely avenues of approach, to tie tank-proof terrain into the defensive plan, and to provide for early warning – a function of reconnaissance units and infantry outposts. Terrain was classified as 'armour-proof' (Panzerschier) – impassable to AFVs; 'armour-risk' (Panzergefährdet) – difficult for AFVs; or 'armour-feasible' (Panzermöglich) – passable to armour. This determination was made by map and ground reconnaissance. Armour-proof terrain included dense forest, swampland, deep mud, numerous large rocks and gullies, steep slopes, railroad embankments or cuttings.

Anti-tank guns were well dug in and concealed, positioned in twos and threes, and emplaced in depth throughout the regimental defensive sector. Selected single guns might begin picking off tanks at maximum range, but most held their fire until the target was within 300 to 150 yards. Close combat teams attacked tanks which reached the German battle positions. Once a tank attack was repulsed the guns moved to alternative positions.

The Germans learned that the massive effort expended in laying vast minefields was wasted, since they were so easily breached. They mainly laid small delaying minefields on routes and within their positions to knock out marauding tanks. Anti-tank ditches were no longer dug well forward of the front line because they provided enemy infantry with jump-off cover; they were now dug immediately in front of fighting positions. The 'armour defence centre of resistance' (Panzer-abwehr-geschutz) was established on the suspected tank approach route, where weapons were concentrated.

A US soldier examines 8.8cm RPzB 54 *Panzerschreck* rocket launchers. Late in the war the Wehrmacht regimental 'armour destroyer company' possessed 54 of these, which were typically employed in groups of six covering the same area.

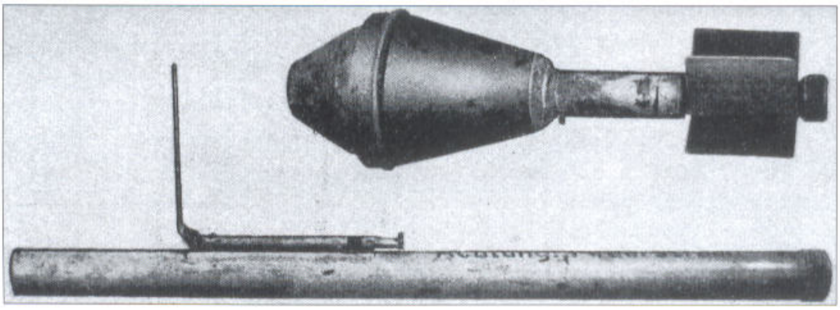




This *Panzerfaust 60* was the most common of several models produced. The sight was folded down until the weapon was readied for firing. When using a *Panzerfaust* from a trench the firer had to be careful that the back-blast was not deflected into his confined position by a rear parapet. Most *Panzerfausts* were painted dark ochre yellow, but some field-grey. They were marked in red on the tube: *Vorsicht! Starker Feuerstrahl!* ('Danger! Intense fire flash!'), with an arrowhead pointing to the rear. Operating instructions were printed on the lower portion of the projectile.

Tank-hunter teams (Panzerjagdgruppe) consisted of an NCO and at least three men well trained in AT close combat techniques and equipped with weapons to 'blind, halt, and destroy'. Such teams were employed only as a last resort, when there were no AT guns operational or a position had been overrun. Machine guns and mortars concentrated on separating enemy infantry from their tanks. Small arms were directed against tank vision ports, and the team moved under cover of smoke grenades. If possible they would lie in wait for the tank to come within 20 yards before attacking with close-combat and expedient weapons. After Panzerfausts became available they were the preferred method of attack, fired in barrages from multiple directions. Tank-hunter teams would move in close and attack from the rear or sides. Close-range ambushes were set up in woodland and built-up areas. Riflemen covering the close-in attacker would cease fire if it hampered him, but be prepared to fire if the crew opened a hatch to defend the tank. Once a tank was disabled and captured, its gun breechblocks would be removed and the tank set on fire.

In 1943 the Germans in Russia developed the *Pakfront* ('armour defence gun front'). This was an extension of the idea of emplacing AT guns behind the forward positions to engage tanks after they broke through, when their fighting formations were less organized and they might be separated from their supporting infantry; Soviet tanks often broke through in large numbers. The concept was for the divisional AT battalion (corps and army level battalions were also employed) to position six to ten or more well dug-in and concealed 7.5cm guns under a single commander, on favourable terrain blocking the main tank routes. Their towing vehicles were hidden close by, ready to relocate or



The *Panzerfaust 30* is depicted here with its warhead removed. The thin sheet metal fins 'unwrapped' when the warhead was launched. While it is similar in appearance to the *Panzerfaust 60*, the folding sights are of distinctly different design.

withdraw the guns quickly. In effect, the Pakfront ambushed tanks at short range, with all guns opening fire simultaneously. Artillery and rocket projectors supported the Pakfront while available reserves and armour moved into a counter-attack.

Japan

Japan was dismally ill prepared for anti-tank warfare *(taisensha sento)*, and suitable weapons were almost non-existent. Although they had been out-manoeuvred when they faced Soviet armour in Manchuria in 1939, they downplayed the decisiveness of armour, persisting in the view that tanks were infantry support weapons. There was no doctrine for massing armour or engaging in battles with enemy tanks. They expected their enemies to follow suit, and made the mistake of judging that only light US tanks would be committed to Pacific islands. In the event, from the November 1943 Tarawa assault onwards the US habitually employed M4 Sherman medium tanks, and later some tank destroyers.

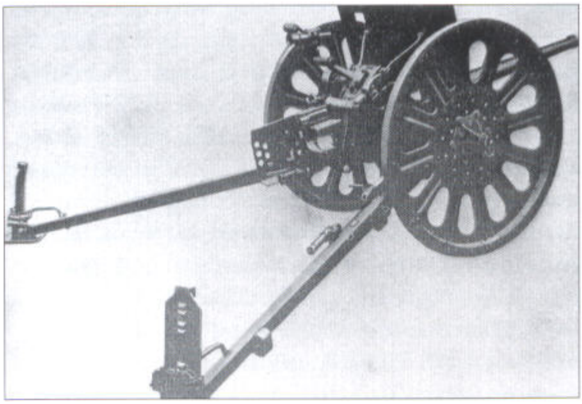
The principal Japanese 'AT' gun was the 37mm Type 94 (1934) infantry rapid-fire gun. Originally intended to deliver direct fire to knock out machine gun nests, it was provided with HE ammunition. Although an AP-HE round was issued, it performed dismally as an AT gun owing to its low velocity and poor penetration – just 24mm at 500 yards. The Type 94 was light and could be broken down into six sections for animal or man-pack transport by its eight-man crew. Some units deploying from China were armed with more effective 37mm Type 97 (1937) AT guns; these were German-made PaK 35/36s captured from China, but were very few in number.

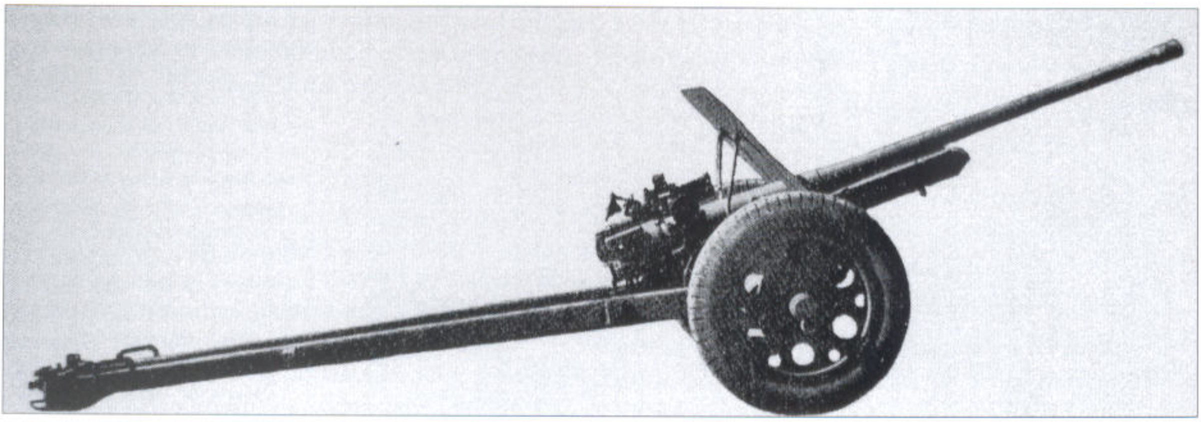
From late 1942 the 47mm Type 1 (1941) AT gun began to appear. While not as effective as similar contemporary weapons, it could knock out a Sherman, but seldom with a frontal shot. Its AP round could penetrate 50mm at 500 yards, and it was also provided with HE ammunition. Infantry regimental AT companies had three two-gun platoons with either 37mm or 47mm guns. Even late in the war they were often still armed with 37mm pieces, and most 47mm guns were found in independent AT battalions, which might possess a mix of the two calibres. There were no divisional AT battalions.

Machine cannon units were armed with 20mm Type 98 (1938) automatic cannon and 13.2mm Type 93 (1933) heavy machine guns. Both were capable of AA fire, but were especially valuable as anti-boat and anti-amphibian tractor guns when provided with AP ammunition.

The 20mm Type 97 (1937) AT rifle was issued to some infantry battalions, with up to eight in the battalion gun company. This was an expensive weapon and few units actually received it; at 150lb (68kg) it was cumbersome, requiring a three to four-man crew. It was capable of semi- and fully-automatic fire, an unusual feature fora weapon fed by a seven-round magazine. Mounted on a bipod and a butt monopod, it had a violent recoil. AP-tracer and HE-tracer ammunition was provided, the former penetrating 12mm at 200 yards.

The Japanese 37mm Type 94 (1934) was originally adopted as an infantry rapid-fire gun. While provided with an AP-HE round, it was an extremely poor AT weapon. It was capable of a high rate of fire because of its breechblock design, but it had a slow traverse.





The Japanese 47mm Type 1 (1941) AT gun. The Japanese were extremely proficient in positioning these and other weapons in well camouflaged positions to achieve flank and rear shots at the US Shermans during the late war island battles, and under such circumstances they did achieve 'kills' despite their mediocre performance.

Little use was made of AT rifle grenades. The Germans provided plans for their cup-discharged 30mm and 40mm grenades, and modified copies were produced as the Type 2 (1942) grenades – one of the few uses made of the shaped charge concept by the Japanese.

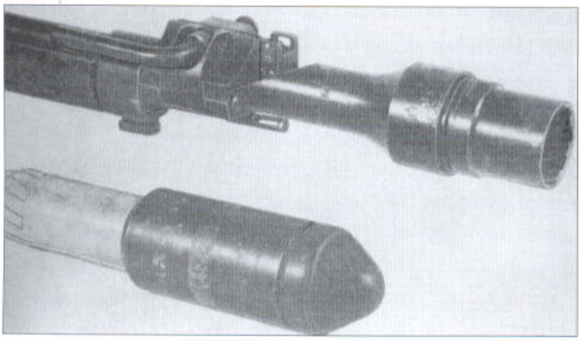
Another shaped charge weapon was the lunge mine, basically a hand-delivered AT mine attached to a pole. First used in the Philippines in 1944, it consisted of an 11.8lb (5.3kg) truncated cone-shaped warhead fitted with stand-off 'prongs' and mounted on a 6ft pole. The attacker rushed a tank, slamming the charge into its side; he did not survive, but the mine could penetrate 150mm of armour.

The Type 99 (1939) magnetic anti-armour charge was a canvas-covered 2lb 11oz charge formed as a flat disc 1.5in thick x 4.75in diameter, and fitted with four magnets around the outside edge. Relying on blast, it was effective only against the thinner side and top armour, being able to penetrate 25mm of plate. The fuse was struck on a solid object to ignite it. Several types of expedient AT grenades and hand mines of marginal effectiveness were mass-produced in the Philippines in 1943–44.

* * *

Japanese AT tactics were characterized by their emphasis on offensive spirit, on efforts to offset their inadequate weapons, and on the close terrain in which much of the fighting occurred. The value of strength of will, to the point of self-sacrifice, in overcoming the materiel superiority of Japan's enemies was a powerful and prevailing belief. While Westerners tend to dismiss such intangible aspects, this suicidal aggression was nevertheless a viable factor, though with obvious limitations; 'one soldier for one tank' was a common credo, but the mathematics were usually costlier than that. Rugged, close terrain – either covered with dense vegetation, or broken ground with gorges, ridges, hillocks and sinkholes – provided AT weapons with cover and concealment, as well as allowing the Japanese to concentrate on close attacks and to maximize the effect of their short-ranged weapons.

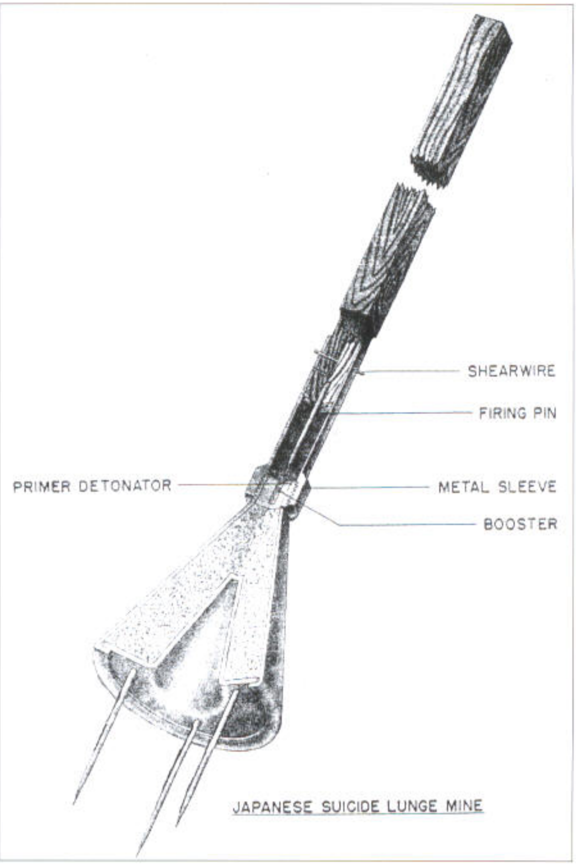
While organic divisional AT assets were limited, one to three independent AT battalions and machine cannon units might be attached to a division. Anti-tank guns were dug in well



One of the few Japanese weapons employing shaped charges was the 30mm Type 2 (1942) grenade based on the German *Schiessbecher* cup discharger system. It could be fitted on Arisaka 6.5mm and 7.7mm rifles, and fired both 30mm and over-calibre 40mm (shown here) AT grenades. Their penetration was approximately 30mm and 50mm respectively, with a range of about 100 yards.

forward, though some would be positioned in depth, and others commonly protected flank and rear approaches. Secondary positions were prepared in the position's depth and on the flanks. Camouflage was excellent; anti-armour engagements were basically ambushes, as they would open fire at very short ranges with guns positioned for side and rear shots. Guns were often dug into ridges and rocky slopes inaccessible to tanks. In rough terrain numerous guns were concentrated on the few routes available to tanks.

Tank-hunter teams of six to eight men under an NCO were formed by each infantry platoon. The men sometimes worked in pairs: one with a Type 99 hand mine, a grenade and a smoke candle, the second with two each Molotov cocktails, grenades and smoke candles. Other tank-hunters organized into a diversionary team with smoke candles; a track team with hand-laid 'yardstick' AT mines or pole charges; a turret team with Type 99 hand mines or satchel charges; and a covering group of riflemen with hand grenades. The covering rifle platoon forced the tank to 'button up', while machine guns and 50mm grenade dischargers ('knee mortars') strove to separate the infantry as the tanks approached.



The 2.9kg (6.4lb) of explosives in the warhead of the lunge mine *(shitotsu bakurai)* was pushed back with its detonator onto a firing pin when slammed into the side of a tank. Three 5.25in rods protruding from the base of the cone ensured optimum 'stand-off' for the hollow charge. US troops called this suicide weapon an 'idiot stick', but it did knock out tanks. Circular Type 93 (1933) AT mines ('tape measure mines') were also fastened to the ends of poles for the same purpose.

The fewer AT guns available, the more tank-hunter units would be formed. Each was given a sector in which to deliver its 'shock attack', as the tank entered an area where the unit was concealed. Attack sites were selected at points where the tank would have to slow down, such as when crossing a stream or gully. One Japanese document stated that attackers should 'voluntarily jump on the tank and throw a grenade inside or stab the crew with a bayonet'. Nevertheless, in April–May 1945 on Okinawa the causes of US tank losses were mines, AT guns, artillery, and attacks with magnetic hand mines and satchel charges – in that order.

On Iwo Jima in February–March 1945, USMC tanks were hampered almost as much by the chaotic terrain as by Japanese AT defences. The soft volcanic sand caused many tanks to throw tracks or bog down. The Japanese tied tank ditches and minefields into terrain features, to channel tanks into the fields of fire of 47mm AT guns, which proved effective at short range; in one such action three Shermans were immobilized within minutes by turret hits. Losses were high; by the operation's fourth day the 4th Tank Bn listed 11 of their tanks destroyed, eight damaged, and 28 operational; the 5th Tank Bn had lost 13, with four damaged and 34 operational.

Losses continued to mount, and the battalions were hard pressed to field enough tanks. In some instances the Japanese use of non-AT weapons actually prevented the commitment of tanks. When tanks advanced with accompanying infantry the Japanese would barrage the area with mortars and grenade dischargers, causing infantry casualties;

The goal of all infantry AT weapons is to halt, disable and destroy tanks. This US Marine M4A3 Sherman on Iwo Jima shows a range of protective additions: track plates around the turret, sandbags and road wheels on the engine deck, and thick wooden planks along the hull sides.

in some clearing operations the Marine infantry declined the use of armour in order to avoid the heavier fire they attracted, and painstakingly cleared pillboxes and caves with bazookas, demolitions and flamethrowers instead. The Japanese often sited pillboxes on terrain inaccessible to tanks to prevent flamethrower tanks from moving within range; these were particularly feared and hated, and often suffered close-in attacks.

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PLATES TEXT

A: TANK VULNERABILITIES

Except to the tank's immediate front and the direction in which the turret was oriented, the crew were for all practical purposes blind. Many of the means of vision were mounted high to maximize their fields, and stealthy and courageous infantry could easily move into the tank's blind zone or 'dead space' *(Toter-Raum)*. This might extend out as far as 20 yards **(diagram, B),** within which a prone or crouching infantryman was invulnerable to the main gun **(1)** and co-axial machine gun **(2)**. Within perhaps a 10-yard inner zone **(diagram, A)** he could not be seen or engaged from pistol/sub-machine gun ports **(3)** or by hand grenades tossed from a hatch such as the turret side escape hatch **(4)**. (The Germans developed an HE-fragmentation cartridge for the 2.6cm flare pistol; fired out of a pistol port, it detonated after a one-second delay.) Of course, the width and configuration of these zones varied from tank to tank and changed as the turret rotated.

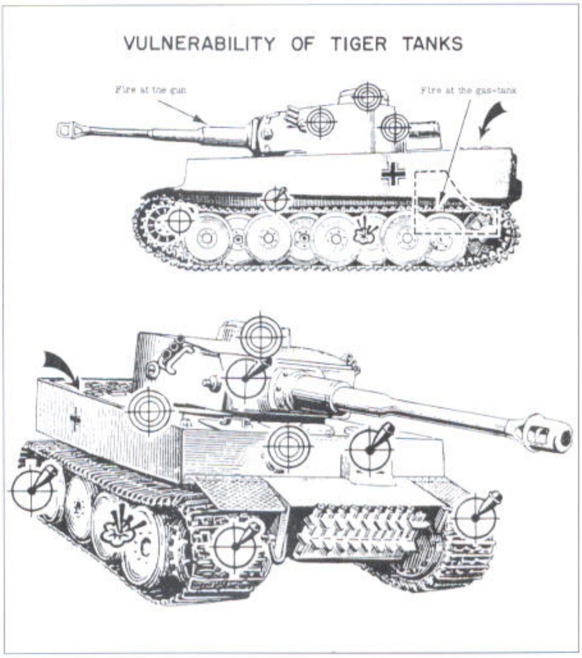
The driver **(5)** and bow machine gunner **(6)** could only see directly ahead and a few degrees to either side. The turret gunner had a very narrow field of vision through the gun sight, and only in the direction the main gun was pointing. The commander had the best field of vision through vision blocks or slits in the low cupola **(7),** and possibly a periscope set in or beside the hatch. Tank commanders preferred to operate with their hatches open to maximize observation, but even in the absence of artillery or mortar opposition they could be forced to 'button up' by small arms fire. This tank is fitted with three-tube smoke grenade projectors **(8)** on either cheek of the turret; triggers inside the turret projected smoke bombs out to about 25 yards, providing a smoke screen to conceal the tank if engaged.

Here, in North-West Europe, an American infantryman rushes a PzKw IV Ausf H tank (for clarity, we have omitted the extra 'stand-off' armour plates normally fixed outside the turret and hull sides of late model Panzer IIIs and IVs). The GI carries a 20lb M1 satchel charge containing eight 2½lb tetrytol blocks – more than enough to halt the tank if thrown on the engine grating or in the tracks; once it is immobilized it will be easy prey for bazookas. The most favourable direction from which to attack was the quarter behind whichever direction the turret was oriented **(diagram, C)**, unless it was facing to the tank's rear. Very few tank designers considered this and mounted a machine gun in the turret rear, but they were provided in most Japanese medium tanks and the Soviet BT-8, KV-1, and IS-1 and -2. The major threat to attacking infantry in this rear quadrant was machine-gunning by accompanying tanks, which the Americans called 'back-scratching'; they might even fire HE rounds at or near friendly tanks to rid their comrades of clinging infantry.

B: GENERIC COMPANY ANTI-TANK DEFENCE

Regardless of nationality, a rifle company established in a defensive position followed a fairly common pattern; the primary differences were due to the numbers and types of AT weapons. This basic deployment of two platoons forward and one in support was employed in most defensive situations, differing according to specific strengths and local conditions.

Security outposts **(1)** are established well forward to warn of the enemy's approach and hamper enemy patrols. Beyond the company outposts are screening forces from battalion, regiment, and division. Most available AT weapons **(2)** covered armour-favourable terrain, while machine guns **(3)** covered terrain restrictive to tanks, as this was the primary infantry approach. Anti-tank obstacles **(4)** were created across the front – here, 10in driven posts – if time and resources allowed, and tied into natural obstacles **(5)**. Bridges were blown **(6)**, point minefields laid at chokepoints **(7)**, and roadblocks established **(8)** – here, an abatis of felled trees. Infantry AT weapons – AT rifles, bazookas or PIATs – were usually allocated on the basis of one per platoon; they might be assigned to each platoon or employed in a single grouping. One, two or more light AT guns **(9)** might be attached from battalion or higher to augment the defence, especially on terrain favourable to tanks. The 'tankable' approaches would also be targeted by artillery and mortar concentrations to separate the infantry from the tanks. Some infantry AT weapons might be employed in the company rear to provide depth to the defence or secure a flank, or be attached to a tank-hunter team. One or more tank-hunter teams **(10)** might be established by the support platoon and possibly the forward platoons to engage tanks which penetrated the front line defences. Anti-tank mines were sometimes laid around platoon positions or on flank approaches **(11)**.



This translated diagram from a Soviet manual shows the vulnerabilities of a PzKw VI Tiger I – a 'T-VI' in Red Army parlance. Standard symbols indicate the most effective weapons for use against various points. The 'gun sight' symbol means 'use all weapons'; the shell and crosswires, 'use guns of all calibres'; the arrow, 'throw incendiary bottles'; and the explosion, 'use AT grenades'. Note the position of the internal fuel tank is also indicated.

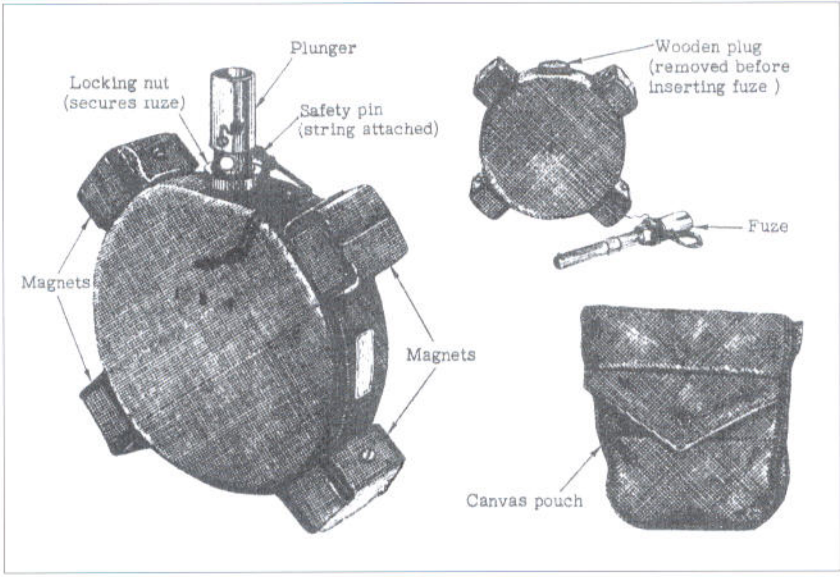
C: INFANTRY ANTI-TANK WEAPONS, 1939–40

The first campaigns of the war found most countries' infantry relying on a variety of comparatively simple weapons for AT defence, and those carried by this German tank-hunter team typify the range available.

The AT rifle, here a 7.92mm PzB 39 Panzerbüsche **(1)** with the butt folded, was often the main platoon AT weapon. While range and accuracy were adequate, even in 1939 they were often ineffective against the tanks of the day; the small AP bullets held no HE or incendiary charge to enhance behind-the-armour effects. Chemical smoke was used to blind tanks and screen attacking infantry, but it took time for a sufficient cloud to develop; the tank could simply drive out of it, or might foil infantry attacks by spraying machine gun fire through it. One rifleman **(2)** has Nebelhandgranate (NbHgr) 39 smoke hand grenades and smoke cylinders (Rauchrohr 39). Another **(3)** carries a double charge (Doppel-Ladung), a pair of 1kg TNT blocks fastened to the ends of a short length of wire, to destroy main gun or machine gun barrels by throwing them over the barrel like saddlebags. Another **(4)** has a concentrated charge (Geballte-Ladung) of six Stielhandgranate (Stg) 24 stick grenade heads, with detonators and handles removed, wired around a complete central grenade. Thrown into tank tracks or on top of the turret or engine deck, it might break a track or penetrate up to 60mm of armour. Another rifleman **(5)** is armed with a GG/P40 rifle grenade with a spigot-type discharger on his Kar98k rifle. Like all other rifle-launched AT grenades of this period, it was of poor ballistic design and had a less than effective shaped charge cavity; most armies replaced their first generation AT rifle grenades by 1942/43.

This combination of weapons provided tank-hunters with stand-off engagement (AT rifle, rifle-launched AT grenade), close-in attack weapons to immobilize, disable or destroy (double and concentrated charges), and smoke devices to blind the quarry and screen the attackers. Regardless of weapon, planning and rehearsals were critical to success. Here the squad leader (Gruppenführer) **(6)** briefs his men before deploying for an exercise, even though they are in a combat zone.

A bazooka man peers through the sights of his M9A1 (note locking collar of two-part tube just ahead of the handgrip), while his assistant pulls an M6A1 or A2 rocket from its packing tube – three of these were carried in a slung canvas bag. A connector wire has to be unwound from the rocket tail; holding on to the free end of this, the loader will press the latch which allows the round to be slipped into the end of the tube, and which then holds it secure. He must then wind the free end of the wire around one of the two connector bosses on the shoulders of the tube, before giving the gunner the 'Ready!' signal, while getting well out of the way of the back-blast. (Reconstruction by 29th Div Historical Assoc, photo courtesy Tim Hawkins)



The Japanese Type 99 (1939) AT charge *(99 hako-bakurai)* was small (about 4¾ in x 1½ in without the four magnets), but if two or more could be fastened together they caused a great deal of concern to tankers (see Plate H). It was issued in a canvas carrying pouch, with the fuse packed in a two-piece metal tube under the pouch flap.

D: US ARMY ANTI-TANK AMBUSH, 1944–45

American tank-hunter teams preferred the ambush – long an American tradition – over direct close-in attacks with hand-delivered weapons (not that they would hesitate to climb aboard a halted Panzer and grenade the crew). Close-attack weapons often resulted in needless casualties; stand-off weapons such as the bazooka and rifle grenade were more effective, and also allowed the hunter team to be more widely dispersed instead of concentrating around a tank (for illustrative reasons this scene in the Ardennes shows the team more closely grouped than they would actually be). The dense woodlands of North-West Europe were ideal for this style of combat; GIs, many of whom had trained in the vast pine forests of the southern United States, often excelled in such tactics.

Tank-hunter teams were built around a 12-man rifle squad, though these were typically understrength – as here. The weapon of choice was the 2.36in M9A1 bazooka with M6A3 HEAT rocket **(1)**; manned by a two-man crew, it had a practical range of less than 100 yards, and in woodland the tank might be engaged at only about 20 yards. The bazooka was operated by a pair of the team's riflemen, all of whom were trained in its use. A grenadier armed with an M9A1 AT rifle grenade propelled from an M7 launcher on an M1 rifle **(2)** provides back-up; it was only effective for side or rear shots. An M19 WP smoke rifle grenade **(3)** lies in readiness to blind the tank or accompanying infantry as the team withdraws.

A rifleman crouches ready with a Mk IIA1 fragmentation grenade, and an M15 WP hand grenade **(4)**; this was a bursting-type grenade that instantly created a large, dense cloud to blind and distract. It also scattered burning gobs of white phosphorus for anything between 18 and 30 yards – dangerous for an incautious thrower. The squad's .30cal M1918A2 Browning Automatic Rifle **(5)** would engage accompanying infantry to drive them away from the tank; sometimes a .30cal M1919A4 light machine gun crew was attached to the team for more firepower. One or two riflemen would always be deployed for rear security **(6)**. The squad leader **(7)** would give the signal to spring the ambush by opening fire himself and shouting 'Fire!' The 50-ton PzKw V Panther was a tough nut to crack; its upper glacis was 80mm thick, the lower glacis 60mm, the turret front 110mm, gun mantlet 120mm, hull sides 50mm, and turret sides and back 45mm – all enhanced by its well-sloped armour design.

E: BRITISH ANTI-TANK ROADBLOCK, 1943–44

Mountainous Italy was a challenge to tank troops. Villages were typically built on dominating mountainside ridges, approachable only by narrow exposed roads easily obstructed by mines and roadblocks. A physical roadblock was seldom used, since this forewarned advancing armour; instead, well-concealed positions were prepared covering a section where tanks were exposed. If the lead vehicle could be disabled it trapped those following, which were vulnerable to intense artillery fire – as will soon be experienced by this StuG III 7.5cm assault gun and SdKfz 251/1 halftrack.

It was virtually impossible to dig in on the rocky terrain, so positions were built with the most available material – loose rocks, stacked in low circular walls. From the British Army's long experience of the Indian North-West Frontier, such a position was called a *sangar*; it had to appear like a natural rock pile if it was not to be detected. The PIAT **(1)** replaced the Boys AT rifle and No.68 AT rifle grenade in mid-1943. Once it was cocked the bomb was inserted in the open-topped semi-cylindrical tray, and launched by a trigger pull. The discharge was supposed to re-cock the 200lb spring, but sometimes failed to do so; it was almost impossible to re-cock manually under exposed combat conditions. Another problem with the PIAT was that when aimed downhill the bomb could slide out of the muzzle. The 3.5in Mk IA HEAT bomb **(2)** weighed 3lb and could penetrate 4in (100mm) of armour, but the point-detonating, base-initiating fuse reduced its potential effectiveness.

The No.75 or 'Hawkins' AT grenade **(3)** was actually a small mine that could be buried or thrown depending on the type

of detonator fitted. Five or six would be placed across a road; here, strung together in a 'necklace' or 'daisy-chain' at 2ft intervals, they are being pulled across the approaching vehicle's path. Heavier conventional AT mines could be linked in the same manner. One rifleman lies in wait with a No.77 WP smoke grenade **(4)**, and a No.73 'thermos flask' AT grenade **(5)**. The latter contained 3¼lb of powerful polar ammonal gelatin dynamite or nitrogelatin; it could penetrate up to 2in of armour, but was more effective when aimed at the tracks. Weighing 4½lb, and measuring 11in x 3¼in, this grenade could only be thrown 10 to 15 yards. It was fitted with an impact-detonating fuse, armed (like the No.77 WP) when the weighted tape of the 'Allways' system unwound in flight and pulled out the safety pin. A Bren light machine gun team **(6)** is placing suppressive fire on the personnel carrier.

F: SOVIET ANTI-TANK DEFENCE IN BUILT-UP AREA, 1944

Despite the weight and bulk of the bolt-action PTRD-41 and semi-automatic PTRS-41 AT rifles (PTR = *protivotankovoe ruzhe*), the Red Army retained them throughout the war, long after AT rifles had been withdrawn by other countries. Although the shorter of the two models, the PTRD-41 was over six feet in length **(1)**. The rifles had extremely good penetration for their class, but side and rear shots at close range were necessary when taking on later German tanks. The AT rifleman's dream shot was to be in the right place at the right time to take a belly shot as a tank mounted an obstacle. The forward portion of the belly of a PzKw V Panther was 26mm thick, but because of the angle of incline as the tank climbs, the 14.5mm (.57cal) bullet, even with an incendiary load, does not guarantee a kill. Another weapon the Soviets retained and even continued to develop was the AT hand grenade. The RPG-43 was the second Soviet design, and the first with a shaped charge **(2)**. If it struck at right angles it could penetrate 75mm, so attack from above a tank was the optimum method – a Panther's turret roof and engine deck were only 15mm thick. Pulling the pin allowed the rear cone of the thrown grenade to slide off the handle and act as a drogue at the end of the deploying streamers **(3)**. Another weapon the Soviets used long after it fell from all but emergency use in other armies was the 'Molotov cocktail' **(4)** – what the Russians called a 'bottle with flammable mixture' *(butylkas goryuchej smes'yu),* since it was thought disrespectful to use the name of the USSR's Foreign Minister as slang. They provided 'incendiary liquid kits', consisting of two long glass tubes filled with sulphuric acid, to be attached to gasoline-filled vodka or cognac bottles by rubber bands; when the bottle shattered upon impact the acid reacted with and ignited the gasoline. Molotovs were widely used; in fact, some 100 men of ad hoc 675-man 'worker's battalions,' manned by untrained factory workers, were armed only with these expedient weapons. Sub-machine gunners **(5)** were deployed for close protection of AT rifle crews, and to shoot Panzergrenadiers **(6)** off tanks. It was not possible to bury AT mines in paved streets, although they could be hidden under a light layer of debris or concealed in a barricade to await tanks attempting to crash it. Often they were simply laid openly on a street; so long as they were covered by fire to prevent them from being removed by escorting infantrymen, they were as effective as buried mines. These TM-38 mines **(7)** are emplaced to catch a tank by surprise when it turns a corner. Between 440 and 660lb weight was required to detonate the 6lb (3.6kg) charge of TNT.

G: GERMAN *PANZERKAMPFGRUPPE* IN COVERING POSITION, 1944–45

As the tide turned against them on all fronts, and they faced overwhelming enemy armour with little of their own, the Wehrmacht excelled in small scale delaying actions. By 1944 the German Army was well equipped with a variety of potent man-portable AT weapons; just as importantly, they knew how to use terrain, natural and man-made obstacles (the stream here is fordable), and how to integrate other weapons into the defence. The mission of this small armour battle group, in an armour defence centre of resistance *(Panzerabwehrgeschutz)* or covering position *(vorge-schobene Stellung)*, is to delay the approach of British tanks **(1)** on a secondary route into a defended village (off the edge of the picture). Such a group would fight stubbornly until ordered to withdraw, or would disengage at a specified time. This sometimes mystified their opponents, who might be engaged in a desperate fight when, without apparent reason, the Germans melted away. Pre-planned artillery barrages would then strike the recently abandoned position.

Point AT minefields were laid at chokepoints **(2)**, inter-mingled with anti-personnel mines. The latter not only hampered sappers clearing them, but might also prevent recovery crews from reaching disabled tanks, and thwart infantrymen and forward observers from using the hull as cover. The few AT guns available at this date were often employed singly, like this 5cm PaK 38 **(3)**, rather than in larger groups; 2cm FlaK guns were positioned on flanks **(4)** to help make up for the lack of AT guns. A single squad with six 8.8cm RP54 Panzerschrecks have taken up positions in a typical pattern **(5);** each 'bazooka' crew has dug a narrow V-shaped slit trench, clustered in threes with two forward and one to the rear. These were dug in open areas to provide wide fields of fire, and spoil was removed to make them hard to spot. This arrangement allowed the Panzerschrecks to engage tanks approaching from any direction, and provided an in-depth defence; at least two of the launchers could engage any tank. The top of the 'V' was oriented toward the enemy; the gunner would move into the arm of the 'V' offering the best angle to the target, his assistant loading and taking shelter from the back-blast in the other arm. While there are farm buildings in the area, only a few snipers occupy them **(6);** buildings attracted suppressive fire and allowed the enemy to pinpoint German positions quickly. Scattered pairs of grenadiers hide on tank routes armed with a few Panzerfausts, ready to engage tanks that might slip through **(7)**. With rifle strength reduced in many grenadier units, higher allocations of MG34 and MG42 machine guns **(8)** were made to increase firepower. These were put to good use separating infantry from the tanks they escorted. British tankers speak of hearing MG bullets striking their hulls and accompanying infantrymen 'squealing like rabbits'.

The different weapons were frequently assigned fire sectors covering other positions, anticipating that they would eventually be abandoned and occupied by the enemy. As the enemy approached the position 8cm and 12cm mortars

Tank destruction badges

Soldiers who successfully attacked a tank with a hand-held or hand-placed weapon sometimes received standard awards for valour, or at least a posthumous wound decoration. In some instances a special award was bestowed. Both the German and Finnish badges, worn on the upper right sleeve, were awarded to men destroying tanks with *Panzerfausts*, *Panzerschrecks*, hand and rifle grenades, satchel charges, hand mines, etc.

Germany instituted the *Sonderabzeichen für das niederkämpfen von Panzerkampfwagen durch Einzelkämpfer* on 9 March 1942, but eligibility was backdated to 22 June 1941, the first day of Operation 'Barbarossa'. The 8.5cm x 3cm silver-coloured braid stripe with black edges bore a bronze PzKw IV tank. When a fifth award was earned a single gold braid badge replaced preceding badges. Oberstleutnant Günter Viezenz, Grenadier Regt 7, received the highest number of awards: 21 – four gold and one silver badge.

Finland instituted a *Panssarintuhoojamerkkion* on 28 June 1944, backdated to 1 June; AT and tank gunners were also eligible for this. A 7cm x 3cm white backing was printed with a light brown T-34 tank. White 7cm x 1cm bars were sewn above the badge when three, five, ten, and 15 tanks were destroyed. The highest number destroyed with hand-held weapons was eight, by L/Cpl Villi Väisänen, 2nd Border Jäger Bn, with *Panzerfausts*.

The US 505th Parachute Infantry Regt established an unofficial award for bazooka gunners knocking out a tank during the 10 July–17 August 1943 Sicily campaign. The 3in x 2in olive drab patch depicted a brown bazooka with a yellow lightning bolt, and was worn on the left breast pocket.

German *Unteroffizier* squad leader, armed with an MP40 sub-machine gun and displaying two Tank Destruction Badges and the Close Combat Clasp.

from the main battle position would fire on pre-registered barrage areas **(9)**. Assault guns **(10)** might be positioned to the rear, usually dug-in or hidden in buildings to further deter the advance. The US Army judged that extensive permanent fortifications such as the *Westwall* ('Siegfried Line') only enhanced the German defence by 15 per cent over defences comprising field works only. Dug-in German tanks and assault guns were given an efficiency rating of 40 per cent and were considered much more troublesome than bunkers.

H: JAPANESE SELF-SACRIFICE, 1945: 'TEN MEN FOR ONE TANK'

Most Marine tanks on Iwo Jima were lost to mines, followed by AT guns; this battle saw the widest use of mines, including buried aerial bombs and torpedoes, which obliterated tanks and amtracs. However, a number were destroyed by desperate close-in infantry attacks. In one action involving 12 tanks, one bogged down in sand 10ft from a cave, and was swarmed by 30 to 40 Japanese. (After disabling the guns and radio, the entire tank crew managed to fight their way out.) The Japanese commander on the island was much concerned by the USMC's M4A3 Shermans, fearing that his 47mm Type 1 (1941) AT guns could not defeat them (an exaggerated fear, as it turned out.) He ordered preparations to use the Type 99 (1939) magnetic AT hand mine *(99 hako bakurai)*, a simple weapon which was moderately effective against hull side and top armour **(1)**. The Marines fitted 2in thick planks to the sides of many Shermans; they protected hatches by welding festoons of nails on top, points upwards, or covering them with welded rod cages giving 5in of stand-off. Like tankers on all fronts, they fastened spare track sections to turret sides and hull fronts, and placed sandbags on the engine deck around intake/exhaust gratings. Most units removed turret top machine guns, to prevent Japanese who clambered aboard from turning them against Marine infantry.

Sometimes two Type 99 mines were wired together to improve penetration. In other instances two pairs of mines were fastened together with small demolition charges sandwiched between them, and the four mines were wired between split logs **(2)**. Though little used, the Type 2 (1942) rifle grenade launcher could fire 30mm and 40mm HEAT grenades, penetrating 30mm and 50mm respectively; the 40mm is illustrated at **(3)**. One fallen soldier has attempted to throw a bar or 'yardstick' mine **(4)** with 6lb of explosive in front of the Sherman's tracks. As a last resort Japanese troops were encouraged to force tank hatches open and attack the crew with grenades – **(5)** is a Type 99 fragmentation – and even bayonets **(6).** In Burma one officer boarded an M3 Lee of the British 3rd Carabiniers and killed the commander and turret gunner with his sword, before being riddled with revolver bullets by the loader.

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ISBN 1-84176-842-1

9 781841 768427